UNDERGRADUATE FINAL YEAR PROJECT REPORT

Department of Mechanical Engineering

NED University of Engineering and Technology

DESIGN AND FABRICATION OF DURABILITY TESTING MACHINE FOR SPRING SEAT OF STRUTS

Group Number: 35 **Batch:** 2017 – 2021

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Approved by

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AUTHOR'S DECLARATION

We declare that we are the sole authors of this project. It is the actual copy of the project that was accepted by our advisor(s) including any necessary revisions. We also grant NED University of Engineering and Technology permission to reproduce and distribute electronic or paper copies of this project.

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STATEMENT OF CONTRIBUTIONS

CONTRIBUTION IN REPORT WORK

S.NO	Group Members	Seat number	Contribution	
1	Umer Rasool	ME-17251	Preface	
			Chapter 1	Project Introduction and Execution Plan
			Chapter 2	Basic Study and Research
			Chapter 3	Machine Theory
			Chapter 4	Machine Design and Calculations
			Chapter 5	Machine Drawings
2	Muhammad Jameel	ME-17212	Preface	
			Chapter 1	Project Introduction and Execution Plan
			Chapter 2	Basic Study and Research
			Chapter 3	Machine Theory
			Chapter 6	Fabrication
			Chapter 7	Conclusion

EXECUTIVE SUMMARY

PROBLEM STATEMENT:

The heavy-duty struts that are attached on the front of the car are integral part of suspension and they support the whole weight of the car. If a failure occurs in this component, it can lead to a catastrophic accident.

So, ensuring the quality and structural integrity of struts is of paramount importance. For this reason, these components are tested excessively and precisely before they are assembled in the car.

The testing process, however requires a prescribed testing apparatus that needs to be in accordance with all the specifications provided by the manufacturer. Agriauto, the sole manufacturer of shock absorbers and struts in Pakistan does not have the said testing equipment in their premises and hence they have to rely on external help from KYB Laboratories in Japan (technical collaboration).

AGRIAUTO INDUSTRIES LTD.

Agriauto is one of the leading automotive components manufacturers in the private sector established since 1981. It stringently follows the Japanese culture of working and because of that it is the only company in Pakistan that has acquired the certification from KYB Corporation Japan & Gabriel Ride Control USA to manufacture genuine automobile shock absorbers and struts in Pakistan.

The products developed in Agriauto are :

- Shocks and struts
- Sheet metal press parts
- Tractor parts
- Automobile window regulators

BACKGROUND INFORMATION:

Although Agriauto has acquired the status of being the sole manufacturer of shock absorbers and struts in Pakistan however, it still lacks the capability of onsite testing and hence it has to rely on KYB laboratories in Japan to examine its products.

A sample of shocks and struts are dispatched to Japan where they wait in que for their turn and upon the availability of labs, the products are tested. The testing process usually takes around one month whereas the waiting time can be around 4 months, making a total time of products testing around 5 months!

METHODOLOGY USED TO SOLVE THE PROBLEM

There are 28 tests in total that are performed in KYB Japan. Although, Agriauto does have the capability to perform 13 of these tests in their factory in Hub, Baluchistan. However, for the rest of the 15 tests, it still has to rely on Japan and as we can comprehend from the information provided above the logistics and the waiting time associated with choosing this option is a real challenge. Hence, our group took the initiative of designing and fabricating Japanese technology right here in Agriauto. The execution Methodology consists of the following steps:

- **Project paper Development:**

We first had to convince the staff of Agriauto that this Project is worth the time and effort. For that purpose, we developed a project paper (refer to fig 1.3) in which we outlined all the benefits along with the design and mechanism of this machine.

- **Gantt chart development:**

The next step was to divide the project into a set of milestones over a reasonable period of time to convey the completion date of the project.

- **Weekly meetings with Mr Kalimullah (GM Tech Agriauto Ltd.)**

Meetings were conducted on a regular basis with Mr Kalimullah at factory premises throughout the course of this project to keep him updated with the progress as well as to learn minute technical details about this project.

- **Design and BOQ development:**

After understanding the testing requirements of Toyota and Suzuki, we started working on the design and the bill of quantity of the machine.

- **Presentation to CEO of Agriauto:**

The design and BOQ of the machine were presented to the CEO of Agriauto. We appealed for funding of project, who very graciously approved.

- **Fabrication and testing:**

After approval of funding, we started procurement of the machine parts and subsequently worked on fabrication. Once Fabrication was completed, we assembled all the mechanical and electrical components and ran trial tests on the machine.

MAJOR ACHIEVEMENTS:

During the course of this project, we learned a lot. Some of our learnings include:

- Industrial Exposure
- Working of various departments in industry
- Designing (Autocad and Solid works)
- Ansys analysis
- Microsoft project Gantt Chart formation
- SAP Software
- Study of various manufacturing processes

CONCLUSION

The project was completed within the allotted time and is now being used by the design and development department in Agriauto.

ACKNOWLEDGEMENT

Foremost, we would like to thank Almighty Allah for blessing us with the perseverance and the capability to complete this project. We are also grateful to our parents and siblings for keeping us in their prayers and encouraging us till the end. This experience was our first step into the practical field and calling it merely educational would be an understatement.

We would like to extend our special thanks and gratitude to our Chairman Prof. Nasiruddin, the faculty of Mechanical department, our project coordinators Miss Ifra Asif and Miss Summaiya Mohsin who attended to our every need throughout the project.

We would like to express our sincerest gratitude to Mr. Muhammad Kalimullah (GM tech) Agriauto pvt ltd. who served as a watch tower whenever we were stuck, who helped us in the formation of ideas that were well above the level of ordinary into something concrete. We are overwhelmed in all humbleness and gratefulness to Mr. Kalimullah for the conduction of knowledge through regular weekly meetings and constant supervision throughout the course of this project. Declaring that this experience has only been possible because of Mr. Kalimullah would not be an overstatement.

We'd be amiss if we did not extend our deepest gratitude to Mr. Muhammad Zahid (Manager PM) for the unwavering and steadfast support throughout the length of this project. His cooperation and technical knowledge have humbled us over and over again.

Any attempt at any level could not be completed without the support, resourcefulness and cooperation of Mr. Tanveer (DGM D&D), Mr. Waqas Talib (HOD PM) and Mr. Zubair (Manager PE).

Finally, we would like to extend our sincere thanks to the workers of Agriautos. Most honorable mentions are Mr. Salahuddin (lathe operator), Mr Saeed (Milling machine operator) and Mr. Mohib (Shaper operator). Their skills in Fabrication have certainly left a great impression on us.

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LIST OF ABBREVIATIONS

AIL	Agriauto Industries Ltd.
AISI	American Iron and Steel Institute.
ASD	Alternating stress diagram
BOQ	Bill of quantity
BMD	Bending moment diagram
CS	Carbon steel
MS	Mild steel
SAE	Society of Automotive Engineers

LIST OF SYMBOLS:

E	=	Ideal Endurance limit of material
Ea	=	Actual value of endurance limit
σ_{allow}	=	Allowable stress
M_b	=	Bending moment
I	=	Inertia
S	=	Section modulus
σ_{max}	=	Maximum Stress
σ_{min}		Minimum Stess
σ_{mean}	=	Mean stress
R	=	Stress Range
Wcr	=	Critical load for column
Dm	=	Mean diameter of bolt
θ_{lead}	=	Lead angle
θ_{thread}	=	Thread angle
D_b	=	Diameter of bolts

UNITED NATIONS SUSTAINABLE DEVELOPMENT GOALS

The Sustainable Development Goals (SDGs) are the blueprint to achieve a better and more sustainable future for all. They address the global challenges we face, including poverty, inequality, climate change, environmental degradation, peace and justice. There is a total of 17 SDGs as mentioned below. Check the appropriate SDGs related to the project.

☐ No Poverty

☐ Zero Hunger

☐ Good Health and Well being

☐ Quality Education

☐ Gender Equality

☐ Clean Water and Sanitation

☐ Affordable and Clean Energy

☐ Decent Work and Economic Growth

☐ Industry, Innovation and Infrastructure

☐ Reduced Inequalities

- ☐ Sustainable Cities and Communities
- ☐ Responsible Consumption and Production
- ☐ Climate Action
- ☐ Life Below Water
- ☐ Life on Land
- ☐ Peace and Justice and Strong Institutions
- ☐ Partnerships to Achieve the Goal

SIMILARITY INDEX REPORT

Following students have compiled the final year report on the topic given below for partial fulfillment of the requirement for Bachelor's degree in Mechanical Engineering.

Project Title _____

_____

S. No.	Student Name	Seat Number	Signature
1.	_____	_____	_____
2.	_____	_____	_____
3.	_____	_____	_____
4.	_____	_____	_____

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Group Number 35

ORIGINALITY REPORT

11%	8%	2%	8%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	www.azom.com Internet Source	2%
2	libx.bsu.edu Internet Source	1%
3	gctbooks.files.wordpress.com Internet Source	1%
4	Submitted to Higher Education Commission Pakistan Student Paper	1%
5	Submitted to University of Houston System Student Paper	1%
6	en.wikipedia.org Internet Source	<1%
7	Submitted to University of Adelaide Student Paper	<1%
8	wburke26.wixsite.com Internet Source	<1%
9	www.slideshare.net Internet Source	<1%

CHAPTER 1:

1) PROJECT INTRODUCTION AND EXECUTION PLAN

1.1 PROJECT TITLE: DESIGN AND FABRICATION OF DURABILITY TESTING MACHINE FOR SPRING GUIDE OF STRUTS

Agriauto is the sole strut manufacturer in Pakistan. Struts are one of the most important parts of a vehicle's suspension system. To ensure the safety of vehicle, struts must pass through a series of vigorous tests before installation.

Durability examination of spring seat of strut is one of these tests. It is a performance testing technique used to determine the structural toughness of spring seat under heavy load conditions. This testing helps us to identify the stability of outer shell of struts including spring seat under cyclic load over the duration of the test.

We are given a task as a Final Year Project by Agriauto Industries ltd. to design and fabricate a machine for the purpose of durability testing of spring seat of different samples of struts that are being manufactured in Agriatuto.

1.2 PROJECT RATIONALE

As we know that struts are one of the most important parts of automobile suspension. For the safety of passengers, testing of struts is necessary to make sure that they can fulfill intended task without any failure under defined conditions.

A number of tests for different parts of shock are done to ensure that the shock absorber will not fail during work. Some of these tests are impact testing, static bending strength testing, shock tube static testing etc.

Many testing facilities for shock absorbers/struts are not available in Pakistan that includes Durability testing of spring seat of struts. Agriauto sends its manufactured parts to Japan for said testing procedure.

Our project will provide Agriauto industry with the in-house testing technology of spring guide.

1.3 BENEFITS AND SIGNIFICANCE:

- The durability testing is done in Japan. This machine will provide Agriauto with the indigenous capability of testing right here in Pakistan.
- The transportation cost for sending parts abroad and costly test charges will be reduced.
- Less time will be consumed for testing due to in-house capability.
- Purchasing machine from abroad will cost more than designing one here.

EXECUTION METHODOLOGY

1.3.1 TEAM FORMATION

Our team constitutes of three undergrad students that have been assigned the project, one external coordinator and one external supervisor from Agriauto and two internal coordinator from NED university.

NAME	ROLE	RESPONSIBILITY
· GM Sir Kaleem	· External coordinator	● Guidance in matters related to the project
· Sir Adnan	· External Advisor	
· Miss Ifrah	· Internal Coordinator	
· Miss Sumayya mohsin	· Internal Coordinator	
· Umer Rasool	· Undergraduate student of NEDUET	● responsible for the application of engineering knowledge for design and fabrication of the most efficient machine.
· Fakhar Zaidi	· Undergraduate student of NEDUET	
· Muhammad Jameel	· Undergraduate student of NEDUET	

Fig 1.1 The team formation

1.4 MINUTES OF MEETING FORMAT

Weekly meetings were held between group members and the external coordinator GM Agriautos Mr Muhammad Kaleemullah. The meetings were documented using the following MOM format.

Project Review - Minutes				
5-Sep-20				
12:00 -14:45				
S.No.	**Participants**	**S.NO**	**ABSENTEES**	
1		1		
2		2		
3		3		
4		4		
5		5		
Agenda 1:				
	Discussion points:			**Discussed by**
1				
	Decision		**RESPONSIBLE**	**TARGET DATE**
AGENDA 2:				
	Discussion points:			**Discussed by**
1				
2				
3				
4				
5				
6				
	Decision(s)		**RESPONSIBLE**	**TARGET DATE**
1				
2				
3				
4				
5				
6				
AGENDA 3				
	Discussion points:			**Discussed by**
1				
	Decision(s)		**RESPONSIBLE**	**TARGET DATE**
1				

Fig 1.2 format of minutes of meeting

1.5 PROJECT APPROVAL

In accordance with the policies of Agriauto industries, a project paper containing rationalization and costing of the project must first be submitted before approval.

Project - Design and Fabrication of a Durability Testing Machine For a Shock Absorber

Team Members:

(1)Umer Rasool (**leader**) (2) Muhammad Jameel (3) Syed Fakhar Abbas Zaidi

Objective: (A)

to design and fabricate a machine that tests durability of the case damper of a shock absorber.

Rational (B)

The concept and applications of this project are:
- Agriautos sends it's shock absorbers abroad for durability and testing. our aim is to provice indigenous capability.
- The outcome of this new facility will result in cost reductions for Agriautos.
- 'shock absorber will be 'ready to go' in a lot less time than before.

EXPECTED CHALLENGES: (C)

the challenges expected are as follows:
- designing and simulation.
- Mechanical Assembly.
- Electrical Assembly.
- software development for the machine.
- stress analysis.
- logistics
- limiting cost of the project.

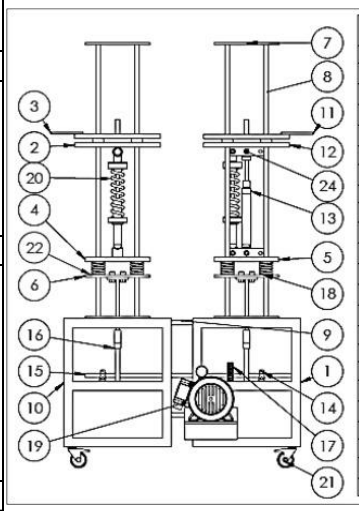
STRENGHTS: (D)

- CAD designing.
- Structural analysis software ANSYS
- Team unity.
- Familiarity with Agriautos' culture and the way things are done in the factory.
- good understanding of engineering subjects.
- All members have knowlege that's not limited to only just theory.
- good understanding of stresses and strains that will occur in a shock absorbers.
- Each group member is hard working and motivated.
- problem solvers.

WEAKNESSES: (E)

- limited electrical assembly knowlege.
- limited knowlege of software development.

Machine concept (F)



ITEM NO.	PART NUMBER	QTY.
1	Active Platform	1
2	Sprung mass passive (Bottom)	1
3	Sprung mass passive (Top)	1
4	Unsprung mass passive	1
5	Unsprung mass active	1
6	Base Plate (Bottom)	2
7	Base Plate (Top)	2
8	Guide Bar	8
9	Table separator	4
10	Passive platform	1
11	Sprung mass active (Top)	1
12	Sprung mass active (Bottom)	1
13	Active Cylinder (Actuator)	1
14	20mm Roller Bearing	4
15	cam	1
16	Follower	2
17	Chain Drive 5:1 Ratio	1
18	Tire spring guide	8
19	Induction Motor 1.12 KW	1
20	Shock Absorber	2
21	Swivel Castor Wheel	8
22	Tire spring	8
23	Screw	8

Financials (G)

Cost Breakup	
Raw material cost	70000 Rs
Electrical cost	200000 Rs
Equipment cost	150000 Rs
hardware cost	10000 Rs
processing cost	80000 Rs
overall cost	**510000 Rs**

Fig 1.3 The project paper

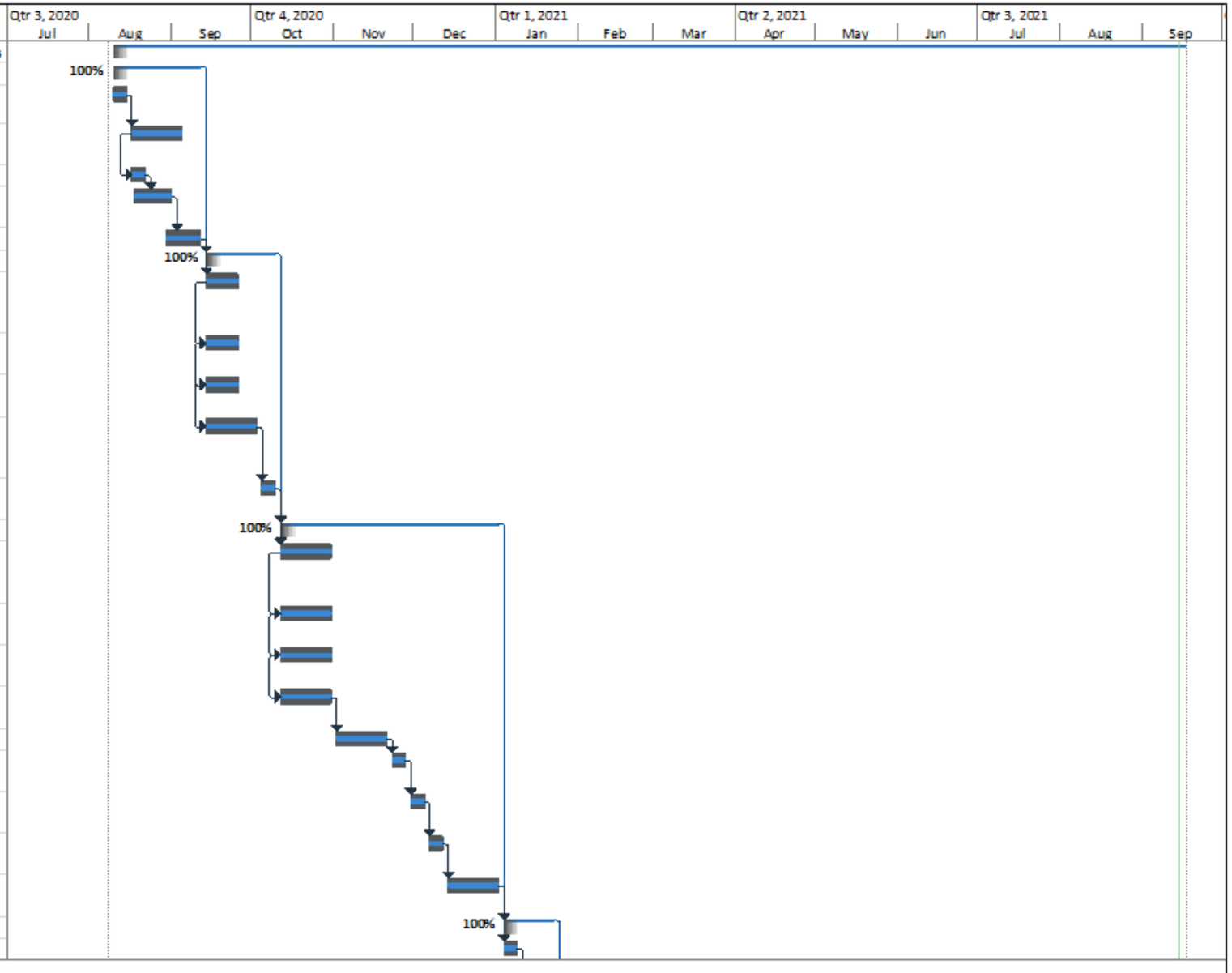
The given Project Paper was submitted to Agriauto industries ltd. It was approved by:

Name: Muhammad Kalimullah

Designation: General Manager Agriautos

1.6 PROJECT DELIVERABLES AND GANTT CHART

ID	Task Name	Duration
1	**Final year project plan**	**290 days**
2	**Project Paper Development**	**25 days**
3	Project concept study and listing benefits for industry	1 wk
4	developing concept design for project paper	3 wks
5	Project Cost Estimations (approx	1 wk
6	Determining scale of project and performng SWOT analysis	2 wks
7	presenting to industry	2 wks
8	**Research On Project**	**20 days**
9	fatigue analysis study from Machines design reference book and forming report.	2 wks
10	stress analysis study from reference book and forming	2 wks
11	binding methodology study from reference book and forming	2 wks
12	mechine mechanism study and driving mechanism alternatives study and forming report	3 wks
13	presenting reports to General Manager of Agriautos for	1 wk
14	**M/c Designing**	**60 days**
15	Overall mechanism (observation from Agriautos and selection) and forming report	3 wks
16	material and beam section selection for structure and	3 wks
17	selection of binding methodology and its specifications and	3 wks
18	selection of driving components and forming report	3 wks
19	assembly drawing on solidworks	3 wks
20	stress analysis of machine parts on ansys	1 wk
21	compiling report of all design parts and calculations	1 wk
22	presenting reports to General Manager of Agriautos for	1 wk
23	designing iterations (incase designing is rejected)	3 wks
24	**Mid Year Evaluation**	**15 days**
25	compiling reports	1 wk



Project: msproj11
Date: Sep 15

Task	External Tasks	Manual Task	Finish-only	Manual Progress
Split	External Milestone	Duration-only	Deadline	
Milestone	Inactive Task	Manual Summary Rollup	Critical	
Summary	Inactive Milestone	Manual Summary	Critical Split	
Project Summary	Inactive Summary	Start-only	Progress	

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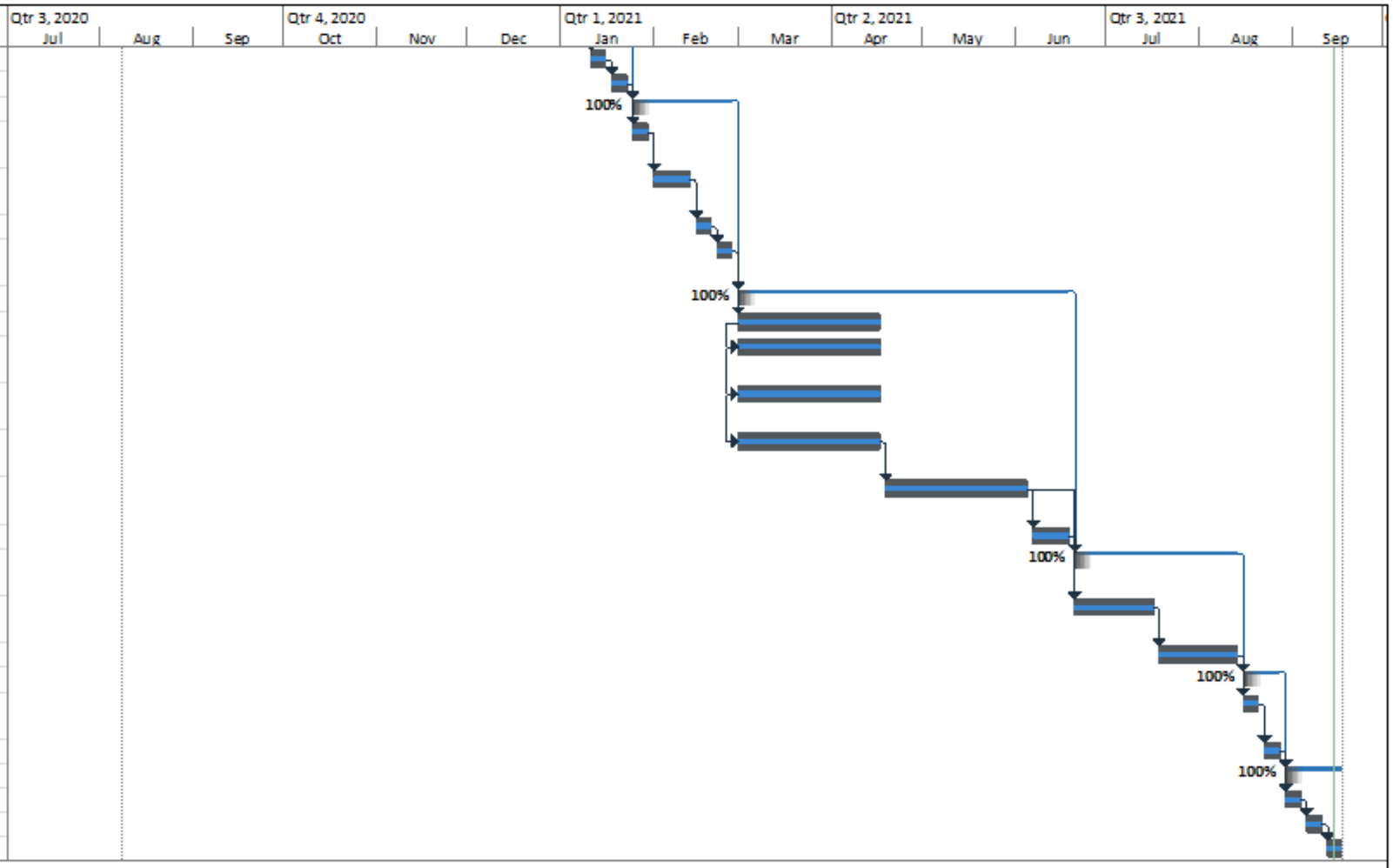
ID	Task Name	Duration
26	making presentations	1 wk
27	presenting to university	1 wk
28	**Bill of Quantity Preparation**	**25 days**
29	Development of bill of quantity on CAD and forming report	1 wk
30	major and minor costing preparation and forming report	2 wks
31	Vendor selection for Fabrication	1 wk
32	presenting data to GM Agriautos for verification	1 wk
33	**Project Fabrication**	**80 days**
34	regular inspection of fabricated p	7 wks
35	bottleneck due to time required for fabrication	7 wks
36	bottleneck due to the unavailability of materials	7 wks
37	bottleneck due to time wastage in logistics of the materials	7 wks
38	observation of processes of fabrication and making report	7 wks
39	Delay due to corona	2 wks
40	**Project Assembly of Mechanical and Electrical Components**	**40 days**
41	observation of process and development of process flow	4 wks
42	daily investigation of assembly pr	4 wks
43	**M/c Testing Trials**	**10 days**
44	machine testing after assembly completion	1 wk
45	making improvements (if required	1 wk
46	**Final Evaluation**	**15 days**
47	compiling reports	1 wk
48	making presentations	1 wk
49	presenting to university	1 wk



Project: msproj11
Date: Sep 15

Task	External Tasks	Manual Task	Finish-only	Manual Progress
Split	External Milestone	Duration-only	Deadline	
Milestone	Inactive Task	Manual Summary Rollup	Critical	
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Project Summary	Inactive Summary	Start-only	Progress	

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CHAPTER 2

2) BASIC STUDY AND RESEARCH

2.1 INTRODUCTION TO THE SUSPENSION SYSTEM OF A CAR:

Suspension is the system of tires, springs, shock absorbers and linkages and many other components that connect the vehicle to the wheels and allow relative motion between them.[1]

2.1.1 FUNCTIONS OF THE SUSPENSION OF A CAR:

The job of a car suspension is to:

- Maximize the friction between the tires and the road surface during acceleration, cruising and braking.
- Provide steering stability with good handling.
- Ensure the comfort.
- Supports weight of vehicle.
- Comfortable ride.
- Allows rapid cornering without extreme body roll.
- Keeps tires in contact with the road surface.
- Allows front wheel to turn left and right for steering.
- Isolates the body from road shocks and vibration
- Prevents excessive body squat and dive. (Squat occurs when accelerating and dive occurs when braking.)

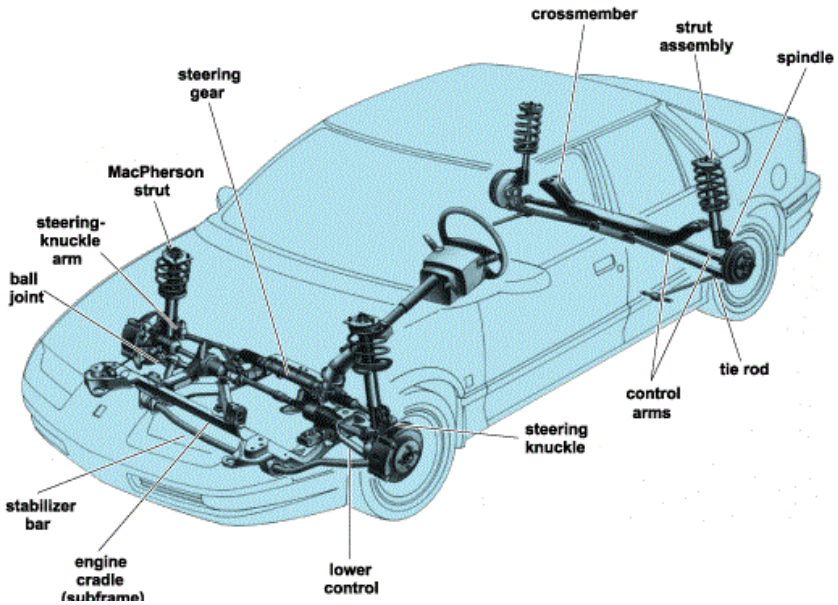


Fig 2.1 Suspension of a car [1]

2.2 TYPES OF SUSPENSION:

Since our project is only related to independent suspension, so we are only going to discuss independent suspension.

2.2.1 TYPES OF INDEPENDENT SUSPENSION:

Independent suspension can be defined as the type of suspension arrangement in which no rigid beam axle is used and both wheels are separately attached. [3]

There are many types of independent suspension. Most commonly used front wheel independent suspension are being discussed here.

2.2.2 DOUBLE WISHBONE TYPE SUSPENSION:

It consists of two control arms for each wheel known as the upper wishbone arm and the lower wishbone arm. These are called wishbone because their shape matches a chicken wishbone. The open end of the both control arms are pivoted to the chassis frame whereas the closed ends are connected to the steering knuckle. The coil spring with the shock absorber is attached between the two control arms. When a car passes over a bump the control arm moves up thus compressing the coil spring. Since there is a damper installed as well, the oscillations are damped as well. [3]

Fig 2.2 Double A suspension

2.2.3 MAC PHERSON STRUT TYPE SUSPENSION

It consists of a single lower wishbone arm that is hinged to the chassis of the automobile. The other end of the wishbone arm is attached to the strut via a ball joint. The strut containing the shock absorber and the spring is attached to the steering knuckle which carries the wheel. The upper end of the strut is connected to the body of the car via a flexible mounting. Here the steering motion of the wheel is provided through the lower control arm. [3]

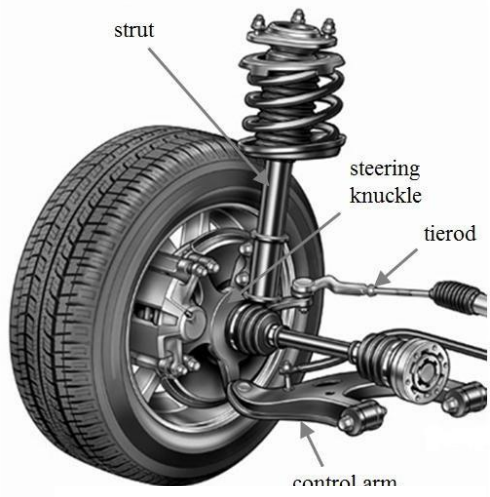


Fig 2.3 Macpherson suspension

2.3 HELICAL SPRINGS:

The helical springs are made up of a wire coiled in the form of a helix and is primarily intended for compressive or tensile loads. The cross-section of the wire from which the spring is made may be circular, square or rectangular.[4] & [5] These types of spring are extensively used in Struts.

2.3.1 HELICAL COMPRESSIVE SPRING:

Compression helical springs are also known as open-coil helical springs. These springs are designed to offer resistance against the linear compressing force applied along their axis. [4] & [5] Compression helical spring gets compressed on the application of load. Based on the design and end type these springs are classified into four types. [4] & [5]

- Closed and Squared Compression Helical Spring
- Closed and Ground Compression Helical Springs
- Double Closed Compression Helical Spring
- Open End Compression Helical Spring

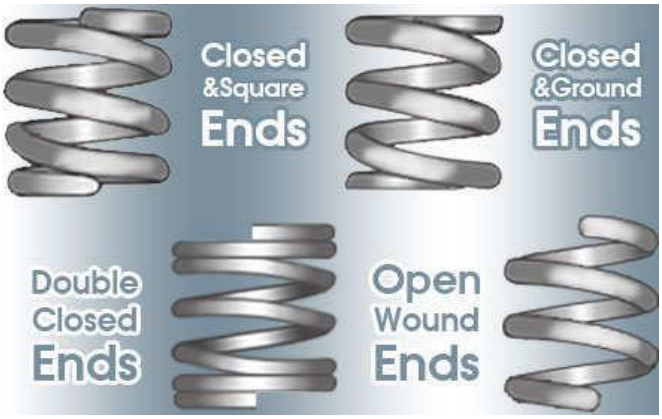


Fig 2.4 Helical compressive springs

2.3.2 HELICAL TENSION SPRINGS:

Tension helical springs, also known as extension springs, are comprised of tightly wound helical coils that are designed to operate in the direction of the tension. The spring stretches to a particular length when a force is applied to it. These springs have hooks at both its ends, and are attached to the product. [4] & [5]

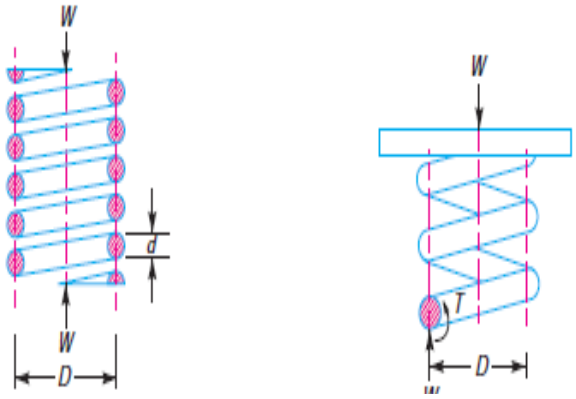


Fig 2.5 Helical Tension springs

2.4 COMPONENTS OF STRUTS

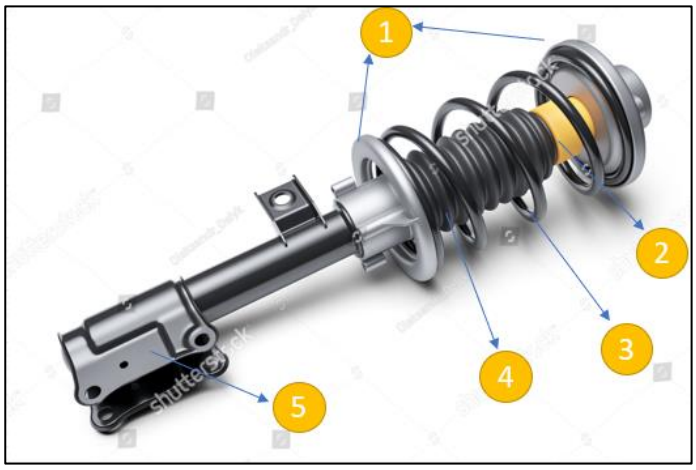


Fig 2.6 Strut assembly

1. Upper and lower spring seat

- provide upper and lower mounting to the compression spring.
- Since the compression spring bears the weight of the whole vehicle, the upper and lower spring seats need to be structurally strong.

2. Bumper

- Absorbs road impact and reduces noise for smoother driving experience

3. Helical Spring

- Responsible for bearing the whole weight of the car.
- It does not dampen any vibration. For that purpose, damper is installed with the assembly.

4. Book kit

- Protect the inner components of damper from dust and particles.

5. Mounting area for steering knuckle

- This is where the Macpherson strut is mounted on the wheel hub.

2.5 DIFFERENCE BETWEEN SHOCK ABSORBER AND A STRUT:

	Shock Absorber	Struts
1	Plays no role in the suspension of a car.	It plays a vital role in the suspension of a car
2	Consists of a piston in a sealed tube which only works to dampen a road shock by means of viscous friction	Modern strut basically consists of a spring mounted on spring seat that is welded on the shock absorber
3	Shock absorber does not support the weight of the car	Struts are responisble for supporting the weight of the car due to the stiffness of the spring.
4	Shock absorbers serve to provide better road quality	Struts ensure constant tyre contact with the road and due to the shock absorber present within the assembly, the also provide some degree of comfort
5	Energy of Shock is dissipated as heat.	small amount of shock is dissipated as heat.
6	A shock absorber is not connected to the wheel hub. It is only connected to the suspension of the car.	MacPherson struts used in Pakistani car directly connected to the wheel hub of the front wheels above the drive shaft along with the steering links. The top portion of the shock is directly connected to the body of the car.
7	Shock absorbers are cheaper than struts.	Struts are costlier and more heavy duty than shock absorbers.
8	Pakistani cars have shock absorbers installed at the rear end of the car.	Pakistani cars have struts installed at the front end of the car.

Table 2.1 Difference between Shock absorber and Strut

CHAP 3:

3) MACHINE THEORY

3.1 MATERIAL FATIGUE AND ENDURANCE LIMIT:

Failure criterion approaches at a stress below the ultimate tensile strength of metals when they are subjected to cyclic loading such as in our case (for some materials, it can occur even below yield strength).[14] The failure may approach by progressive crack formation which are usually fine and microscopic in size.

3.2 TYPES OF CYCLIC LOADING:

There are many types of cyclic loads. Some of them are:

3.2.1 REVERSIBLE STRESS

In this type of loading the variable stress fluctuates between maximum tensile to maximum compressive stress. In this case σm=0. [13]

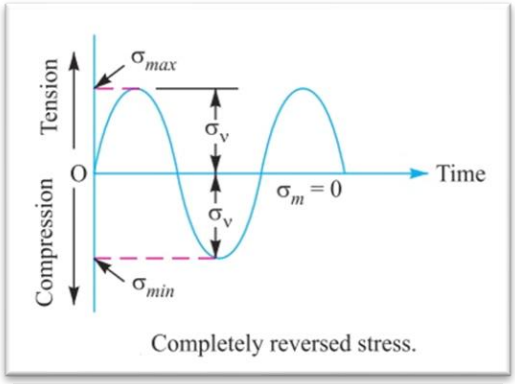


Fig 3.1 Completely reversed stress

3.2.2 REPEATED STRESS

In this case, the fluctuating load ranges from zero to maximum value of a specific kind of stress. In this case σmin=0. [13]

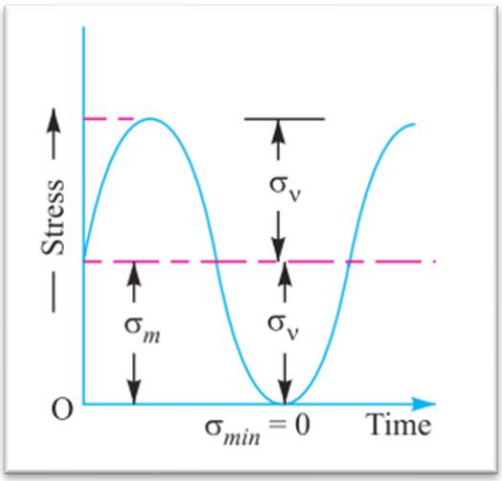


Fig 3.2 Repeated loading

3.2.3 FLUCTUATING STRESS:

M/c parts subjected to fluctuating loads do not have a symmetric stress distribution however, application of more than one kind of stress needs to occur as a condition. [13]

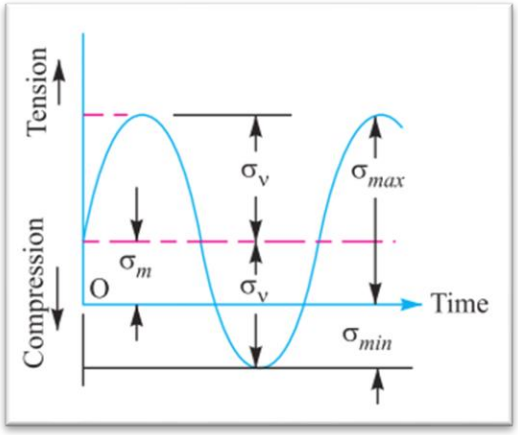


Fig 3.3 Completely reversed stress

3.3 PARAMETERS IN FLUCTUATING LOADS:

Since we're dealing with repeated stress as our stress distribution will range from 0 to max compression on the spring seat. So, we'll start with defining some basic parameters relating to fluctuating loads. [13]

1. **Mean stress:**

$\sigma m = (\sigma min + \sigma max)/2$ [13]

2. **Reversed stress component or alternating or variable stress:**

$\sigma v = (\sigma max - \sigma min)/2$ [13]

3. **Stress ratio:**

$R = \sigma max/\sigma min$ [13]

3.3.1 ENDURANCE LIMIT:

Failure criterion approaches at a stress below the ultimate tensile strength of metals when they are subjected to cyclic loading such as in our case (for some materials, it can occur even below yield strength). [13] The stress limit at which a material can withstand cyclic loads for an indefinite period of time/ cycles, such a stress limit is known as endurance or fatigue limit. [13]

For steel $\sigma e = 0.5\sigma u$ [13]

For cast steel $\sigma e = 0.4\sigma u$ [13]

For cast iron σe = 0.35σu [13]

For non-ferrous metal and alloys σe=0.3σu [13]

3.3.2 DEFINING FAILURE CRITERION:

Before starting the selections for general structure of the machine, it is a good practice to define the failure criterion that the design team will follow.

In regards to the calculations, the failure criterion will be the yielding stress of the selected material as this consideration will theoretically only allow elastic deformation in the parts. With respect to the fluctuating stresses, the design failure criterion will be the Soderberg line as it will provide the safest design.

- failure point → yield point
- failure line → Soderberg line

3.4 TYPE OF LOADING OCCURRING IN A SPRING SEAT:

According to the specifications provided by Agriauto Industries, the durability testing machine has to apply 4500N force on the spring seat for a total of 200,000 cycles. Since the requirement also states that two samples of strut need to be tested at a time so this puts a total of 9000N force on the structure of the machine. This force will range from 0 to 9000N for a total of 200,000 cycles so we're dealing with repeated loading.

Fig 3.4 Lower spring guide

3.5 MATERIAL SELECTION FOR MACHINE STRUCTURE:

The endurance strength is a major factor in the selection of material for the structure of the machine. It is obtained experimentally by S-N graphs or estimated by performing corrections to the ultimate tensile strength of materials.

As shown in figure 3.5, the knee depicts the stability of a material subjected to fatigue

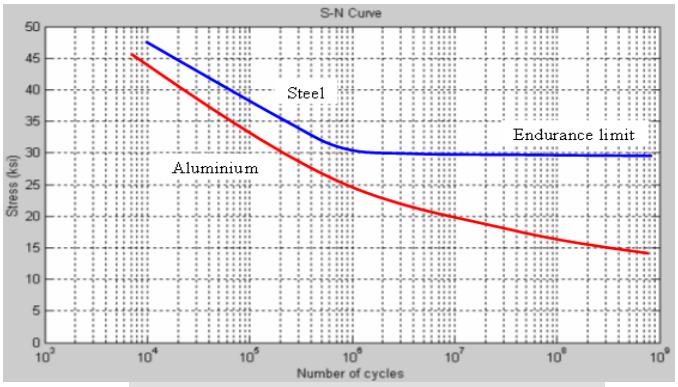


Fig 3.5 S-N graph

loading. Theroretically, the materials which possess a knee can survive fatigue loading for infinite number of cycles.[13]

However, the materials that do not possess a knee in their graph as depicted in fig 3.5, do not possess any endurance strength and are bound to fail sooner or later. Many non-ferrous metals and alloys, such as aluminum, magnesium, and copper alloys, do not exhibit well-defined endurance limits.

3.5.1 ENDURANCE LIMIT IN REGARD TO FERROUS AND NON-FERROUS ALLOYS:

1. Ferrous materials have a distinct feature in which up to a certain critical value fatigue becomes max, while of non-ferrous metals with increasing number of cycles the fatigue increases and leads to failure. The comparison in graphs can be seen in fig 3.6.

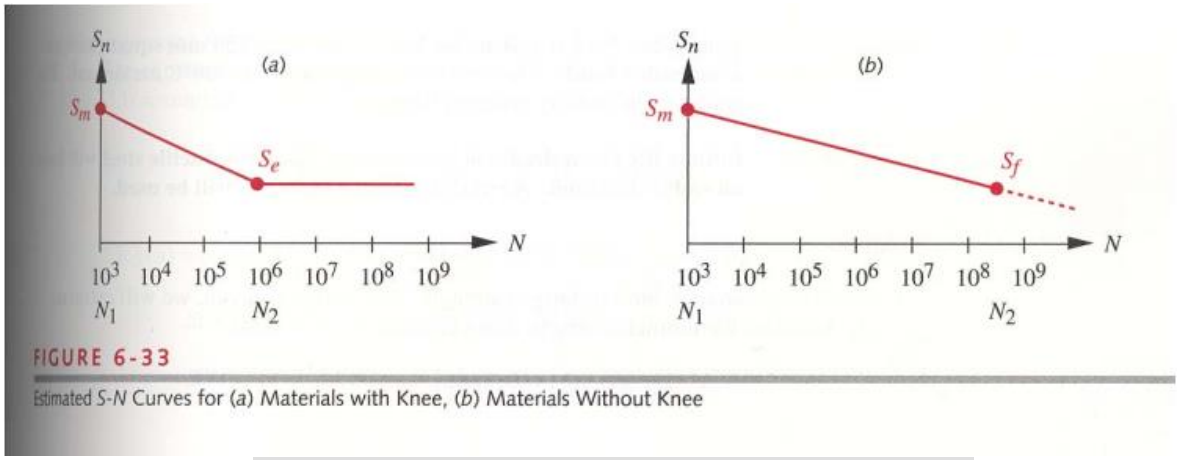


Fig 3.6 S-N graph of ferrous and non-ferrous alloys

2. Ferrous alloys and titanium alloys have a distinct limit below which there appears to be no number of cycles that will cause failure. Other structural metals such as aluminum and copper do not have a distinct limit and will eventually fail even from small stress amplitudes. In these cases, a number of cycles (usually 10^7) is chosen to represent the fatigue life of the material.

3. Titanium alloys and non-ferrous alloys are both far more expensive than ferrous alloys.

3.5.2 COMPARISON OF DIFFERENT MATERIALS FOR STRUCTURE

S.no	Specifications	Non-ferrous alloys	Titanium alloys	Ferrous alloys	judgement
1	Existence of endurance limit.	✖	●	●	All perform equally.
2	Machinability	●	✖	●	Titanium alloys require high machining costs
3	Strength of material	▲	●	●	Aluminium alloys are far more ductile and soft than titanium and ferrous alloys.
4	Cost	✖	✖	●	Ferrous alloys are relatively a lot cheaper than titanium and non-ferrous alloys.
5	availability	▲	✖	●	Ferrous alloys are more common than the other two

Table 3.1 Comparison between materials for structure

● ACCEPTABLE

▲ MARGINALLY ACCEPTABLE

✖ UN-ACCEPTABLE

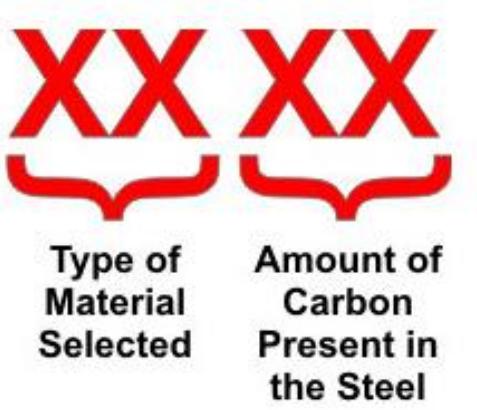
3.6 NAMING AND CLASSIFICATION OF FERROUS ALLOYS:

Alloy steels and carbon steels for a number of years were designated with specific grades by a four-digit SAE/AISI numerical index system. Grades for alloy steels and carbon steels were identified by this system based on standard chemical compositions. [11]

3.6.1 GRADING OF AISI MATERIALS

A basic four-digit system is used by the SAE system to designate the chemical composition of alloy steels and carbon steels.[11] Most of the times, SAE and AISI numbers for materials are the same and are quotes as such.

3.6.2 SCHEMATIC REPRESENTATION OF AISI/SAE NUMBERING SYSTEM:



- The first digit of AISI/SAE Steel Designation represents a general category grouping of steels. This means that 1xxx groups within the SAE-AISI system represent carbon steels.[11] Because of the variations in some of the fundamental properties among the carbon steels, they are further divided into four classes. Thus the plain carbon steels are represented within the 10xx series containing a maximum of 1.00% Mn, resulfurized carbon steels are represented within the 11xx series, resulfurized and rephosphorized carbon steels are represented within the 12xx series, and non-resulfurized high-manganese (up-to 1.65%) carbon steels are represented in 15xx series.[11] The non-resulfurized high-manganese carbon steels are developed for ensuring better machinability.[11]
- The second digit of the series indicates the presence of major elements, which may affect the properties of the steel. For example, in 1018 steel, the zero in the 10XX series depicts that major secondary elements such as sulfur, are not present.[11]
- The last two digits indicate that the carbon concentration. Such as for AISI 1040, the carbon percentage is 0.40%.[11]

3.6.3 LOW CARBON, MEDIUM CARBON AND HIGH CARBON STEELS:

Steels are classified into low carbon, medium carbon or high carbon on the basis of carbon percentage present within them. As the carbon content increases, the metal becomes harder and harder.[11]

low carbon steel→ less than 0.3% carbon

medium carbon steel → 0.3% to 0.6% carbon

high carbon steel → greater than 0.6% carbon

3.7 OBSERVATION AND SELECTION OF MATERIALS IN LAWRENCE ROAD, SADDAR:

The group visited Lawrence Road Saddar for the observation of different types of beams and the materials that are commonly used to manufacture them. On the basis of that visit, we determined that which materials are readily available and up to par with our requirements.

The selected materials were low carbon SAE 1010 steel and medium carbon SAE 1045 steel and K100 steel. The low carbon steel will be used in the beams whereas the high carbon and K100 steel will be used in the fixtures of the machine to provide additional strength.

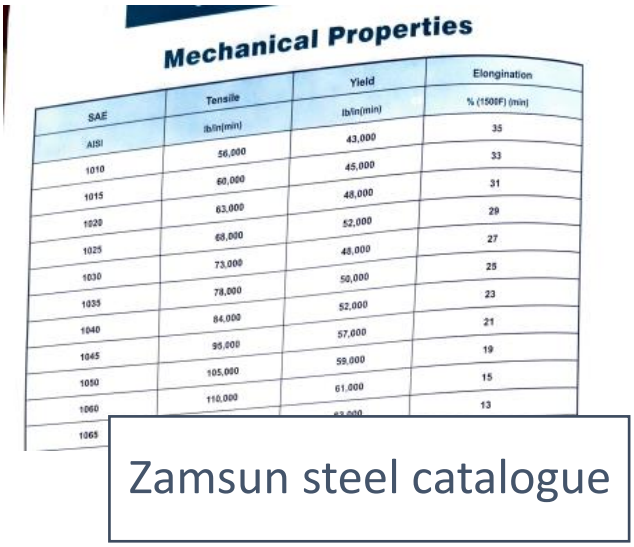


Fig 3.7 Zamsun Steel Catalogue

3.8 MATLAB SCRIPT FILE FOR STRUCTURE SELECTION:

Since designing is an iterative process and requires performing the same calculations again and again, our group came up with a very creative solution to this problem and we made a script file on MATLAB software that instantly performs calculation upon which selection is performed.

SCRIPT FILE

```
clc,clear all
material=input('what is the selected material aisi 1010 or aisi 1040: ','s');
loading=input('type of loading i.e. bending load, shearing load or axial load: ','s');
load_section=input('specify the part on which load is being applied on i.e. is it a column, beam or bolt: ','s');
section_selection=input('specify the section to be selected i.e. beam,column or bolt: ','s');
switch material
   case 'aisi 1010'
      ultimate_tensile=386.10;  %unit is N/mm^2
      yield_strength=296.47456;  %unit is N/mm^2
      elasticity=205000; %unit is N/mm^2

endurance_limit=0.5*ultimate_tensile;
%we know that for steel endurance limit equals 0.5* ultimate tensile strength
      fprintf('the endurance limit is %4.2f N/mm^2 \n',endurance_limit)
   case 'aisi 1040'
      ultimate_tensile=620;  %unit is N/mm^2
      yield_strength=415; %unit is N/mm^2
      elasticity=210000; %unit is N/mm^2

endurance_limit=0.5*ultimate_tensile;
%we know that for steel endurance limit equals 0.5* ultimate tensile strength
      fprintf('the endurance limit is %4.2f N/mm^2 \n',endurance_limit)
   otherwise
    error('rerun')
end
switch loading
   case 'bending load'
      kb=1; %factor for bending load equals 1
      endurance_bending_ideal= endurance_limit*kb;
      %this endurance limit is only applicable to ideal scenarios.
      %for real life scenarios
      ksz=1;
      kt=1;
      ki=1;

endurance_actual=endurance_bending_ideal*ksz*kt*ki;
   case 'shearing load'
      ks=0.55; %factor for shear loads

endurance_shear_ideal=endurance_limit*ks;
      %this endurance limit is only applicable to ideal scenarios.
      %for real life scenarios
      ksurr=1;
      ksz=1;
      kt=1;
      ki=1;

endurance_actual=endurance_shear_ideal*ksurr*ksz*ksz*kt*ki;
   case 'axial load'
      ka=0.8; %factor for axial loads
      %since i have already applied the concept of real and actual
      %endurance limit. this time im going to directly calculate the
      %endurance limit
      ksz=1;
      kt=1;
      ki=1;

endurance_actual=endurance_limit*ka*ksz*kt*ki;
   otherwise
      error('rerun the program')
end
switch load_section
   case 'column'
      ksurr=0.9; %ground surface

endurance_stress=endurance_actual*ksurr;
      fprintf('the endurance stress for column is %4.2f N/mm^2 \n',endurance_stress)
   case 'bolt'
      endurance_stress=endurance_actual;
      fprintf('the endurance stress for bolt is %4.2f N/mm^2 \n',endurance_stress)
   case  'beam'
      ksurr=0.9; %ground surface

endurance_stress=endurance_actual*ksurr;
      fprintf('the endurance stress for beam is %4.2f N/mm^2 \n',endurance_stress)
   otherwise
      error('rerun the program')
end
switch section_selection
   case 'beam'
      length=input('length of the beam in mm: ');
      forces=input('number of forces acting on the beam one,two or three:','s');
      F.O.S=1.5;%factor of safety

allowable_stress=endurance_stress/F.O.S;
      switch forces
         case 'one'
```

```
        p= input('what is the magnitude of force in Newton: ');
        x=[0:0.1:length];
        L=input('what is the distance of application of the force: ');
        moment=((p*(length-L))/length)*x-p*(x-L).*(x>L);
        plot(x,moment);
        xlabel('length');
        ylabel('moment');
        M_max=max(moment);
        fprintf('the maximum moment is %4.2f N/mm \n',M_max)

S=M_max/allowable_stress;%section modulus for the selection of beam
        fprintf('the section modulus is %4.2f mm^3 \n',S)
        I=input('what is the inertia of the selected beam in mm^4: ');
        c=input('what is the height of the section: ');
        max_stress=(M_max*(c/2))/I;
        fprintf('the max stress in the beam is %4.2f N/mm^2 \n',max_stress)
        mat_stress=[0:1: max_stress (max_stress-1):-1:0];
        n=numel(mat_stress);
        min_stress=min(mat_stress);
        cycles=linspace(0,1,n);
        plot(cycles,mat_stress);
        xlabel('number of cycles');
        ylabel('stress');

mean_stress=(max_stress+min_stress)/2;
        range_stress=(max_stress-min_stress)/2;
        if mean_stress+range_stress*(yield_strength/endurance_stress)<=(yield_strength/F.O.S)
            fprintf('the design lies within the Soderberg line and design is safe for infinite number of cycles')
        else
            fprintf('the design lies outside Soderberg line so design is not safe')
        end
    case 'two'
        p1=input('what is the magnitude of first force: ');
        p2=input('what is the magnitude of second force: ');
        x=[0:0.1:length];
        L1=input('what is the distance of application of the first force ');
        L2=input('what is the distance of application of the second force: ');
        moment=(((p1*(length-L1))/length)+((p2*(length-L2))/length))*x-p1*(x-L1).*(x>L1)-p2*(x-L2).*(x>L2);
        plot(x,moment);
        xlabel('length');
        ylabel('moment');
        M_max=max(moment);
        fprintf('the maximum moment is %4.2f N/mm \n',M_max)

S=M_max/allowable_stress;%section modulus for the selection of beam
        fprintf('the section modulus is %4.2f mm^3 \n',S)
        I=input('what is the inertia of the selected beam in mm^4: ');
        c=input('what is the height of the section: ');
        max_stress=(M_max*(c/2))/I;
        fprintf('the max stress in the beam is %4.2f N/mm^2 \n',max_stress)
        mat_stress=[0:1: max_stress (max_stress-1):-1:0];
        n=numel(mat_stress);
        min_stress=min(mat_stress);
        cycles=linspace(0,1,n);
        plot(cycles,mat_stress);
        xlabel('number of cycles');
        ylabel('stress');

mean_stress=(max_stress+min_stress)/2;
        range_stress=(max_stress-min_stress)/2;
        if mean_stress+range_stress*(yield_strength/endurance_stress)<=(yield_strength/F.O.S)
            fprintf('the design lies within the Soderberg line and design is safe for infinite number of cycles')
        else
            fprintf('the design lies outside Soderberg line so design is not safe')
        end
    case 'three'
        p1=input('what is the magnitude of first force: ');
        p2=input('what is the magnitude of second force: ');
        p3=input('what is the magnitude of third force: ');
        x=[0:0.1:length];
        L1=input('what is the distance of application of the first force ');
        L2=input('what is the distace of application of the second force: ');
        L3=input('what is the distance of application of the third force: ');
        moment=(((p1*(length-L1))/length)+((p2*(length-L2))/length)+((p3*(length-L3))/length))*x-p1*(x-L1).*(x>L1)-p2*(x-(L2)).*(x>(L2))-p3*(x-(L3)).*(x>(L3));
        plot(x,moment);
        xlabel('length');
        ylabel('moment');
        M_max=max(moment);
        fprintf('the maximum moment is %4.2f N/mm \n',M_max)

S=M_max/allowable_stress;%section modulus for the selection of beam
        fprintf('the section modulus is %4.2f mm^3 \n',S)
        I=input('what is the inertia of the selected beam in mm^4: ');
        c=input('what is the height of the section: ');
        max_stress=(M_max*(c/2))/I;
        fprintf('the max stress in the beam is %4.2f N/mm^2 \n',max_stress)
        mat_stress=[0:1: max_stress (max_stress-1):-1:0];
        n=numel(mat_stress);
        min_stress=min(mat_stress);
        cycles=linspace(0,1,n);
        plot(cycles,mat_stress);
        xlabel('number of cycles');
        ylabel('stress');
```

```
mean_stress=(max_stress+min_stress)/2;
        range_stress=(max_stress-min_stress)/2;
        if mean_stress+range_stress*(yield_strength/endurance_stress)<=(yield_strength/F.O.S)
            fprintf('the design lies within the Soderberg line and design is safe for infinite number of cycles')
        else
            fprintf('the design lies outside Soderberg line so design is not safe')
        end
    otherwise
        error('rerun the program')
    end
case 'column'
    force_type=input('is the force tensile or compressive: ','s');
    A=input('cross sectional area of the column in mm^2: ');
    l=input('length of the column in mm: ');
    switch force_type
        case 'tensile'
            p=input('what is the force acting on the column in Newton: ');
            max_stress=p/A;
            fprintf('the nominal tensile stress acting on the column is %4.2f N/mm^2 \n',max_stress)
            mat_stress=[0:1: max_stress (max_stress-1):-1:0];
            n=numel(mat_stress);
            min_stress=min(mat_stress);
            cycles=linspace(0,1,n);
            plot(cycles,mat_stress);
            xlabel('number of cycles');
            ylabel('stress');

mean_stress=(max_stress+min_stress)/2;
        range_stress=(max_stress-min_stress)/2;
        F.O.S=1.5;
        if mean_stress+range_stress*(yield_strength/endurance_stress)<=(yield_strength/F.O.S)
            fprintf('the design lies within the Soderberg line and design is safe for infinite number of cycles')
        else
            fprintf('the design lies outside Soderberg line so design is not safe')
        end
    case 'compressive'
        %compressive force in a column will cause buckling.
        %critical load for bucking is given by rankine's formula
        I=input('what is the moment of inertia of beam: ');

Wcr=(endurance_stress*A)/(1+(endurance_stress*A*l^2)/(pi^2*elasticity*I));
        fprintf('the critical load for the column is %4.2f N/mm^2 \n',Wcr)
    otherwise
        error('rerun the program')
    end
case 'bolt'
    p=input('force acting on the bolt in Newton: ');
    n=input('what is the number of bolts: ');

dia=sqrt((4*p)/(pi*endurance_stress*n));
    fprintf('the root/ minor dia of the bolt (dc) is %4.2f mm \n',dia)
    maj_dia=input('what is the major dia of the selected bolt: ');
    minor_dia=input('what is the minor dia of the selected bolt: ');
    pitch=input('what is the pitch of the selected bolt: ');
    depth_of_thread=input('what is the depth of thread of the selected bolt: ' );
    stress_area=input('what is the stress area of the selected bolt: ');
    mean_dia=(maj_dia+minor_dia)/2;

thread_angle=2*atand((pitch/2)/depth_of_thread);
    fprintf('the thread angle of the bolt is %4.2f degrees \n',thread_angle)

lead_angle=atand(pitch/(pi*mean_dia));
    fprintf('the lead angle of the bolt is %4.2f degrees \n',lead_angle)
    max_stress= p/(n*stress_area);
    F.O.S=1.5
    fprintf('the max stress in the bolt is %4.2f N/mm^2 \n',max_stress)
        mat_stress=[0:1: max_stress (max_stress-1):-1:0];
        n=numel(mat_stress);
        min_stress=min(mat_stress);
        cycles=linspace(0,1,n);
        plot(cycles,mat_stress);
        xlabel('number of cycles');
        ylabel('stress');

mean_stress=(max_stress+min_stress)/2;
        range_stress=(max_stress-min_stress)/2;
        if mean_stress+range_stress*(yield_strength/endurance_stress)<=(yield_strength/F.O.S)
            fprintf('the design lies within the Soderberg line and design is safe for infinite number of cycles')
        else
            fprintf('the design lies outside Soderberg line so design is not safe')
        end
    otherwise
        error('rerun the program')
end
```

3.9 FORMULAS USED IN DEVELOPING MATLAB CODE

S. No	Description		Symbol		Formula	Reference
1	Ideal Endurance limit of material	=	E	=	½*UTS	[13]
2	Actual value of endurance limit	=	Ea	=	E*Ka*Ksz*Kt*Ki Where, Ka = Factor for axial load Ksz = Size factor Kt = Temperature factor Ki = Impact factor Incase of bending load, Ka is replaced by Kb	[13]
3	Allowable stress	=	σ_{allow}	=	Ea/F.O.S	[25]
4	Bending moment	=	M	=	F*L Where, F = Force L = Moment arm	[24]
5	Inertia	=	I	=	Depends on section I= 1/12 bh^3 for rectangular section	[24]
6	Section modulus	=	S	=	M_{max}/ σ_{allow}	[26]
7	Maximum Stress	=	σ_{max}	=	F/A (for axial load) = MC/I (for bending load) Where, M = Bending moment C = h/2 I = Inertia	[24]&[25]
8	Minimum Stess		σ_{min}	=	0 (for repeated loading)	[13]
9	Mean stress	=	σ_{mean}	=	$(\sigma_{max+} \sigma_{min})/2$	[13]
10	Stress Range	=	R	=	$((\sigma_{max}-\sigma_{min})$	[13]
11	Critical load for column	=	Wcr	=	Pi^2*E*I/L^2 Where,	[29]

					E= Young's modulus of elasticity	
12	Goodman's proof equation			=	$\sigma_{mean}+R*(\sigma_{mean}/Ea)<=(\sigma_y/F.O.S)$ If this equation is satisfied then our selection is successful and the design will last for infinite number of cycles.	[13]&[14]
13	Mean diameter of bolt	=	Dm	=	(major Dia+minor dia)/2	[16]
14	Lead angle	=	θ_{lead}	=	ArcTan(pitch/(pi*Dm)) Where, Dm = Mean dia	[16]
15	Thread angle	=	θ_{thread}	=	2*ArcTan((P/2)/B) Where, P = Pitch B = Depth of thread	[16]
16	Diameter of bolts	=	D_b	=	Sqrt((4*F)/(pi*Ea*n)) Where, F = load Ea = Actual endurance limit n = Number of bolts	[16]

Table 3.2 Formulas used in Matlab code

3.10 MECHANISM OF THE MACHINE

There are several mechanical options that are suitable for a reciprocating drive. Some of these options are:

- Mechanical drive
- Hydraulic drive
- Screw drive

In these three options, screw drive holds the least merit because of its slow speed. However, Mechanical and hydraulic drives are viable contenders and so, we did a detailed comparison of these drives.

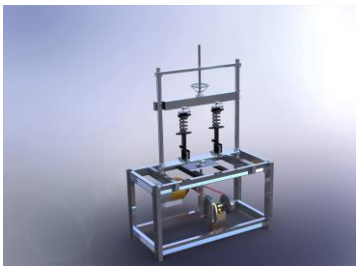
		MECHANICAL DRIVE	HYDRAULIC DRIVE	
				
S.NO	**FEATURES**	**JUDGEMENT**		**REMARKS**
1	Number of components	●	▲	The number of components in hydraulic drive are far more than mechanical drive.
2	Availablity of components	●	●	The components of both drives are readily available.
3	Design simplicity	●	✖	Mechanical design is a lot simpler than Hydraulic design due to less number of components
4	Precision	▲	●	Hydraulic drives are more precise.
5	Working area	●	▲	The working area of hydraulic machines is far more than mechanical machines.
6	cost	●	✖	The cost of hyraulic drive is far more than mechanical drive.

Table 3.3 Comparison between mechanical and hydraulic drive

●	ACCEPTABLE
▲	MARGINALLY ACCEPTABLE
✖	UN-ACCEPTABLE

3.11 BINDING METHODOLOGY OF THE MACHINE

3.11.1 WELDING

The binding methodology of this machine will consist of bolting of parts that may be needed to opened for maintenance and welding of parts that need to be permanently fastened.

The welding operation that are being performed in Agriauto and suitable for our machine are:

S.no:	Type of Weld	Weld Rod	Weld Shield	Weld properties
1	MIG weld	Copper	CO2	Very strong weld used for high thickness materials
2	FCAW	E7018 MS electrode	Flux material	A strong weld that can be used for welding thin metal part(sheets) as well. For welding structure of the machine, we set the ampere to 14 Amps whereas for welding sheets, the amperage is set to 8 Amps

Table 3.4 Welding in Agriauto

Although welding saves a lot of time and it is very strong binding method yet it is avoided as much as possible in the fabrication of this machine because of the development of residual stresses.

3.11.2 BOLTING

The bolts used in this machine will have the following properties:

Property	High tensile
Type	Allen bolt
Grade	12.9
Diameter	Atleast 10mm (refer to section 4.17.2)
Thread	Both full thread and half thread
Length	As per requirement

Table 3.5 Specification of bolts

CHAP 4

4) MACHINE DESIGN

4.1 SPRING SEAT DURABILITY TESTING

- Since springs support the whole weight of the car and springs are mounted on the spring seats, so spring seats should be structurally strong.
- The spring seats are welded on the outer cylinder of the strut. This weldment needs to be tested to ensure safety.
- Springs seats are characterized as “MARU-A” parts.
- **MARU-A** parts are those parts whose failure can result in an accident or fatal injury to the passengers. So, the toughness of these parts is paramount.

Fig 4.1 MARU-A part

4.2 SAMPLES TO BE TESTED

The machine is required to test three different types of struts:

- Toyota Corolla Strut (178B)
- Toyota Yaris Strut (662B)
- Suzuki Alto Strut (Y4J)

Fig 4.2 Rendered strut

4.3 DESIGN SPECIFICATION OF SAMPLES

DESIGN SPECIFICATIONS				
S.No	MODEL	L MAX (mm)	L MIN (mm)	STROKE (mm)
1	COROLLA 778B	513.9	355.4	155.5
2	YARIS 662B	513.9	378.8	157.6
3	ALTO Y4J	468.0	335.7	132.3

Table 4.1 Design Specifications

4.4 TESTING SPECIFICATION OF SAMPLES:

TESTING SPECIFICATIONS				
S.No	MODEL	STIFFNESS(KN/mm)	LOAD (N)	CYCLES
1	COROLLA 778B	27	4500	200,000
2	YARIS 662B	30.5	3900	200,000
3	ALTO Y4J	20	2720	500,000

Table 4.2 Testing specifications

As we can gather from the design and testing specifications, each of the struts have a different stroke, stiffness, testing cycles and size. So, a machine needs to be designed that incorporates all of these provisions.

4.5 DESIGN #1

4.5.1 DESIGN SPECIFICATIONS

The specifications required by Agriauto are as follows:

- Two samples are to be tested at the same time.
- The stroke is adjusted via a crankshaft that has two pin locations.
- The RPM should be adjustable from 50rpm to 150rpm.
- The motor RPM are reduced significantly due to the reduction of forces because of lever mechanism.

4.5.2 MACHINE DESIGN AND MECHANICAL COMPONENTS

The various components of the machine are:

- VFD
- 4 hp motor
- 1:11 gear box
- Crank mechanism with holed crankshaft and crank plate
- Two levers with two fulcrum bearings
- Sliding lower bed
- Adjustable top beam for height

Fig 4.3 Rendered Design 1

4.5.3 MACHINE FEATURES:

ELECTRICAL FEATURES:

- Load cell that dispays load up to 15000N.
- HMI to control motor speed and number of cycles for a strut sample.
- Cycle counter.
- Safety switches.

MECHANICAL FEATURES:

➢ VARIABLE STROKE LENGTH:

The variable stroke is achieved by a crank mechanism that consists of an EDM holed crankshaft.

The holes in the crankshaft are locations for crank plate pins.

Each hole gives a different deflection hence whenever struts samples are changed the crank plate is adjusted to give appropriate deflection.

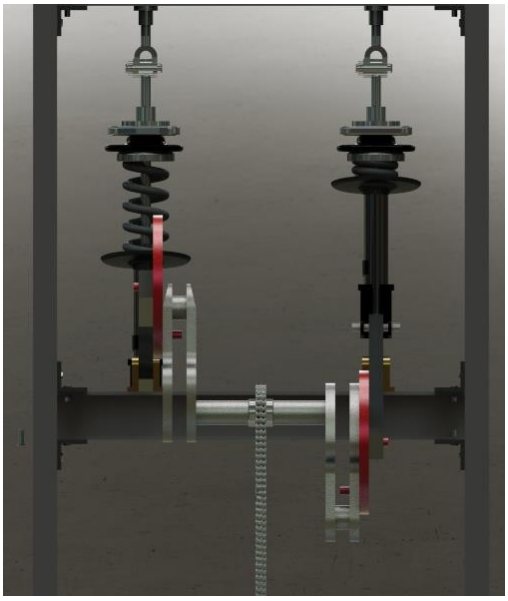


Fig 4.4 Stroke mechanism of Design 1

➢ ADJUSTABLE HEIGHT

The height is adjustable up to 300 mm due to a movable upper beam

The height of the top beam is adjusted with the help of bolt screwed at the top which when rotated, slides the top beam in the vertical direction hence providing height for larger struts to be clamped.

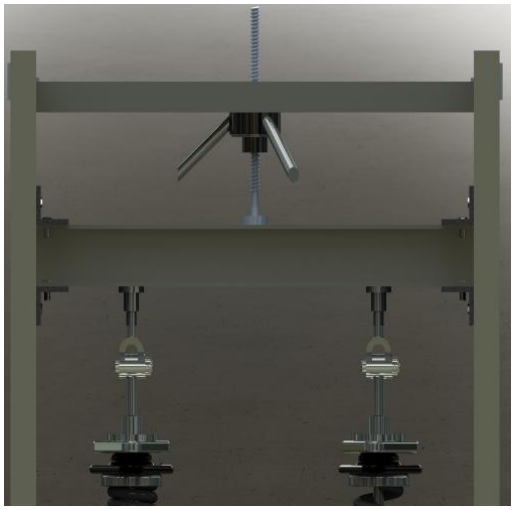


Fig 4.5 Height adjustment of Design 1

4.6 DESIGN #2

4.6.1 DESIGN SPECIFICATIONS

The specifications required by Agriautos are as follows:

- Two samples are to be tested at the same time.
- The stroke should be adjustable upto 230mm
- The RPM should be adjustable from 50rpm to 150rpm.

4.6.2 MACHINE DESIGN AND MECHANICAL COMPONENTS

The various components of the machine are:

- VFD
- 10 hp motor
- 1:11 gear box
- Crank mechanism
- Connecting rod consisting of bearing at each end.
- Multiple bronze and MS bushing
- Sliding lower bed
- Adjustable middle bed
- Fixed top bed

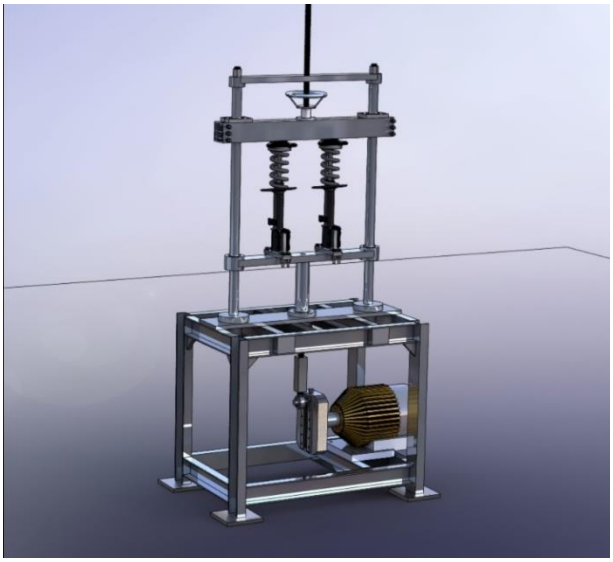


Fig 4.6 Rendered Design 2

4.6.3 MACHINE FEATURES:

ELECTRICAL FEATURES:

- Load cell that dispays load up to 15000N.
- HMI to control motor speed and number of cycles for a strut sample.
- Cycle counter.
- Safety switches.

4.6.4 MECHANICAL FEATURES:

➢ VARIABLE STROKE LENGTH:

The stoke length can be varied via the adjustable crank mechanism.

The nut slides within the groove of the mechanical part and the height of the nut can be adjusted with the help of the bolt.

The stroke length can be adjusted up to 230mm which is in accordance with the testing standards that have been required by Agriauto.

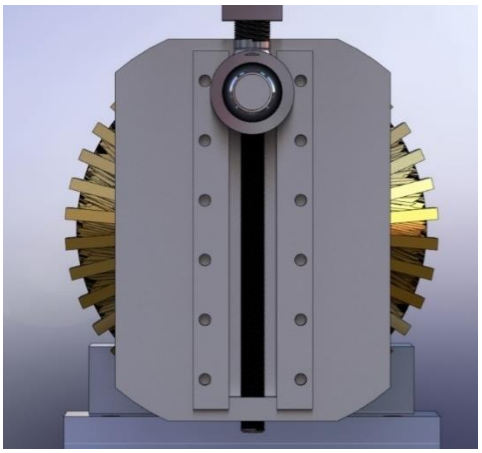


Fig 4.7 Stroke Mechanism of Design 2

➢ ADJUSTABLE HEIGHT

The height is adjustable up to 300mm due to a movable middle bed.

The height of the middle bed is adjustable with the help of bolt screwed at the top which when rotates, slides the middle bed in the vertical direction hence providing height for larger struts to be clamped.

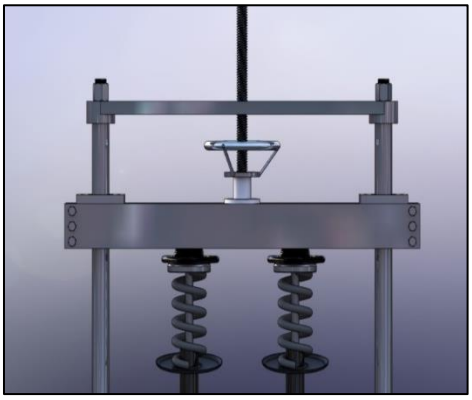


Fig 4.8 Height adjustment Mechanism of Design 2

4.7 FINAL JUDGEMENT OF DESIGN:

Features	Design 1	Design 2
Compact assembly	✖	▲
Complexity of design	✖	▲
Ease of operation	✖	▲
Motor cost	▲	✖
Number of components	✖	▲
Occupied floor area	✖	▲

Table 4.3 Testing specifications

Hence design 2 is selected.

4.8 DESIGN CALCULATIONS

4.8.1 MOTOR SELECTION

Since we opted for the mechanical drive and the power pack of the mechanism is an induction motor, so now we have to define the requirements of the motor.

As we are performing test for three different struts and each strut has different force and cycle speed requirements defined by the manufacturer. We need to calculate required HP of motor for each sample and then compare the obtained values to make a good judgment.

Fig 4.9 Rendered image of Motor

For Suzuki Y4J strut

Specified revolutions per minute:	=	N	=	120 rpm
Specified stroke	=	D	=	132.3
Force exerted by both struts (adding 20% to incorporate any frictional losses:	=	F	=	6528 N
Torque	=	T	=	6528*132.3/(2*1000)
		T	=	431.83 Nm
Power required from motor	=	P	=	(2*pi*N*T)/60
		P	=	2*pi*(120)(431.83)/60
		P	=	5427.535 W
Power required in HP	=	P	=	5427.535*0.00134102
			=	7.277 Hp

Judgement for Suzuki Y4J strut

A 7.277 Hp motor is required for Suzuki strut

For Toyota 178B strut

Specified revolutions per minute:	=	N	=	60 rpm
Specified stroke	=	D	=	155.5 mm
Force exerted by both struts (adding 20% to incorporate any frictional losses:	=	F	=	10800 N
Torque	=	T	=	10800*155.5/(2*1000)
		T	=	839.7 Nm
Power required from motor	=	P	=	(2*pi*N*T)/60
		P	=	2*pi*(60)(839.7)/60
		P	=	5275.99 W

Power required in HP	=	P	=	5275.99*0.00134102
			=	7.07 Hp

Final judgement for motor

8 Hp motor will be adequate to perform all the above tests.

4.9 GEARBOX SELECTION

In the selection of motor, we can see that the rpm requirements of each manufacturer are different, hence for obtaining the desired output speed a gear box needs to be installed. (see table 4.2)

Fig 4.10 Gearbox

Rpm of motor	=	N	=	1400 Rpm
Required Rpm for Suzuki	=	Ns	=	120Rpm
Required Rpm for Toyota	=	Nt	=	60 Rpm
Gearbox ratio	=	Gr	=	N/Ns
		Gr	=	1400/120
		Gr	=	11.667

Final Judgement for Gearbox

A 1:11 ratio gearbox is suitable for our Suzuki strut. However, for the Toyota strut, a variable drive needs to be installed to bring the rpm down to 60 Rpm in the induction motor.

4.10 BEAM SELECTION FOR STRUCTURE

Selection of appropriate beams requires a determination of the beam's section modulus, a geometric property which is a ratio of I to c; I being the inertia and c being the distance of application of force from the neutral axis. By using the flexural formula, we have:

$S_{req'd}$= Mmax/stress allowable

Here Mmax is obtained from the bending moment diagram and allowable stress is specified in the design code.

Once the value of $S_{req'd}$ is obtained, the engineers choose a beam design such that the section modulus of the selected beam exceeds $S_{req'd}$

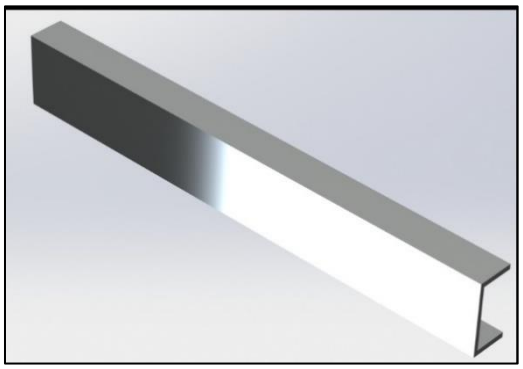


Fig 4.11 C-section

MATLAB COMMAND WINDOW beam

Specify material (AISI 1010 or AISI 1040):	AISI 1010
Specify the type of loading (bending load, shearing load or axial load):	Bending load
Specify the part on which load is being applied on (column, beam or bolt):	Beam
The calculated endurance limit is:	193.05 N/mm^2
The actual endurance stress for beam is:	173.75 N/mm^2
Specify length of the beam in mm:	1000 mm
Specify the number of forces acting on the beam (one,two or three):	One
Specify the magnitude of force in Newton:	10800 N
Specify the distance of application of the force in mm:	500 mm
The calculated maximum moment is:	2700000.00 N/mm
The calculated section modulus is:	23310.02 mm^3

Bending moment diagram

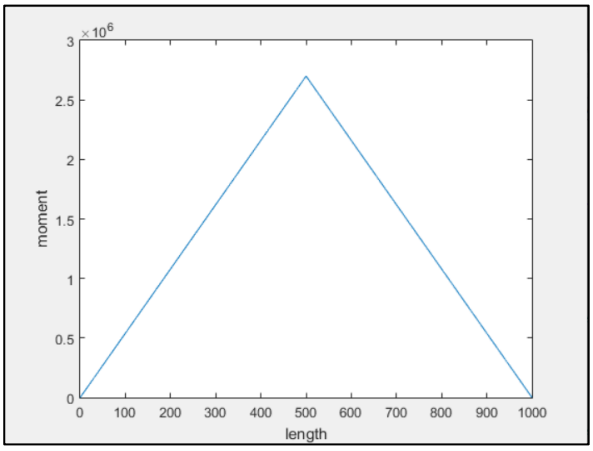


Fig 4.12 BMD of structural beams

Specify the Inertia of the selected beam in mm^4:	2016433.33 mm^4
Specify the height of the section in mm:	100 mm
The calculated maximum stress in the beam is:	66.95 N/mm^2

Maximum alternating stress diagram

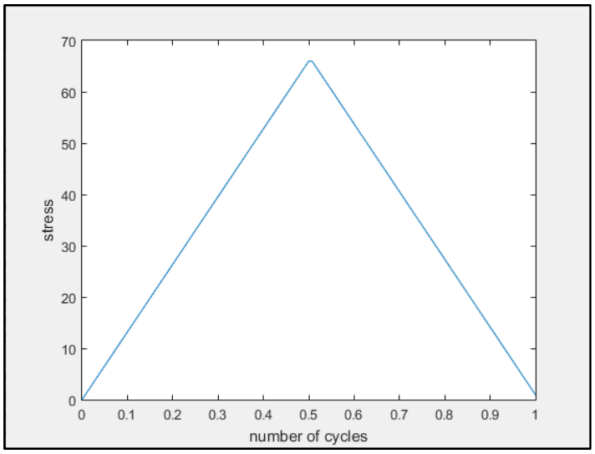


Fig 4.13 ASD of structural beams

Judgement

The design lies within the Soderberg line and design is safe for infinite number of cycles.

4.10.1 SELECTION OF BEAMS:

Using Matlab, three basic beam sections are selected for the structure of the machine. The specifications are:

C section	Angled section	I section
Height of web=100mm	63*63 mm flanges	Height of web= 100mm
Length of flange=50mm	9mm thickness	Flange length=50mm
Web thickness=6mm		Web thickness=6mm
Flange thickness=7mm		Flange thickness=7mm

Table 4.4 Final selection of beams

All of these specifications are obtained from Zamsun Steel Catalogue.

4.11 MIDDLE BED

The middle bed has to be adjustable so it is of extreme importance that the middle bed is light weight to allow movement easily.

Total length of the middle bed is 800 mm with two spring forces acting at 200mm length and 600mm length

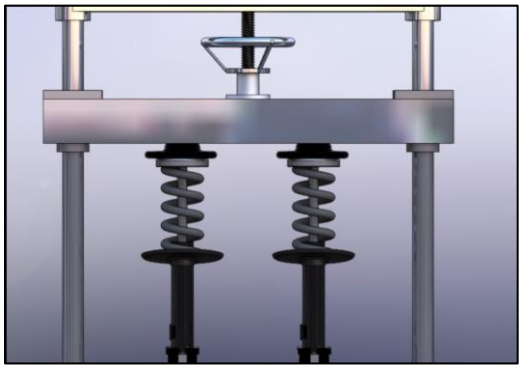


Fig 4.14 Rendered middle bed

Force exerted by one spring	=	4500N
Force exerted by a spring (adding 20% for friction and other losses)	=	4500N+4500(0.2)N
	=	5400N
Distance of application of first force	=	200mm
Distance of application of 2nd force	=	600mm

MATLAB COMMAND WINDOW

Specify material (AISI 1010 or AISI 1040):	AISI 1010
Specify the type of loading (bending load, shearing load or axial load):	Bending load

Specify the part on which load is being applied on (column, beam or bolt):	Beam
The calculated endurance limit is:	193.05 N/mm^2
The actual endurance stress for beam is:	173.75 N/mm^2
Specify length of the beam in mm:	800 mm
Specify number of forces acting on the beam (one,two or three):	Two
Specify the magnitude of first force in Newton:	5400 N
Specify the magnitude of second force in Newton:	5400 N
What is the distance of application of the first force in mm:	200 mm
What is the distance of application of the second force in mm:	600 mm
The calculated maximum moment is:	1080000.00 N/mm
The calculated section modulus is:	9324.01 mm^3

bending moment diagram

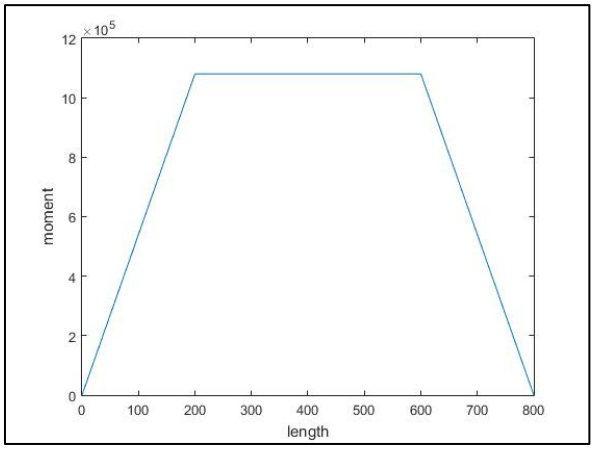


Fig 4.15 BMD of middle bed

Specify the inertia of the selected beam in mm^4:	2016433.33+20164.333 mm^4
Specify the height of the section in mm:	100 mm
The calculated maximum stress in the beam is:	13.39 N/mm^2

Maximum alternating stress diagram

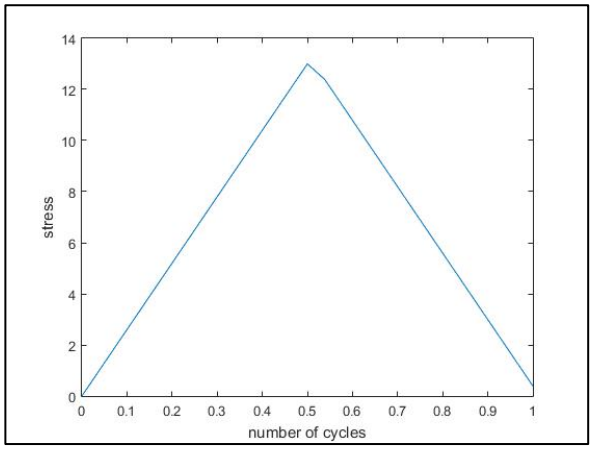


Fig 4.16 ASD of middle bed

judgement

The design lies within the Soderberg line and design is safe for infinite number of cycles.

4.12 LOWER BED

Material selection for bed	=	AISI 1010
Material selection for bushing	=	Bronze
Thickness of bed	=	40mm
Depth of bed	=	100mm
Inertia	=	1/12*b*(h)^3
	=	1/12(100)(40)^3
	=	533333.33m^4
force exerted by each spring	=	5400N (accounting 20% for losses)
Distance of application of first force	=	200mm
Distance of application of 2nd force	=	600mm

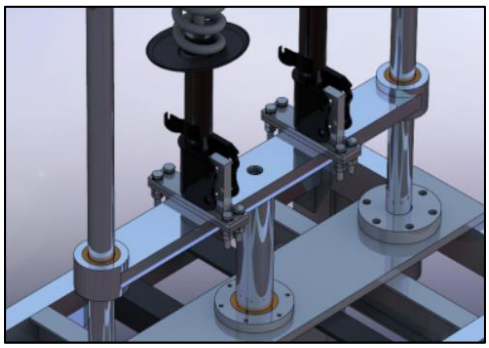


Fig 4.17 Rendered image of lower bed

MATLAB COMMAND WINDOW

Specify the selected material (AISI 1010 or AISI 1040):	AISI 1010
Specify the type of loading (bending load, shearing load or axial load):	Bending load
Specify the part on which load is being applied on (column, beam or bolt):	Beam
The calculated endurance limit is:	193.05 N/mm^2
The actual endurance stress for beam is:	173.75 N/mm^2
Specify length of the beam in mm:	800mm
What is the number of forces acting on the beam (one,two or three):	Two
Specify magnitude of first force in Newton:	5400 N
Specify magnitude of second force in Newton:	5400 N
Specify the distance of application of the first force in mm:	200 mm
Specify the distance of application of the second force in mm:	600 mm

The calculated maximum moment is:	1080000.00 N/mm
The calculated section modulus is:	9324.01 mm^3

bending moment diagram

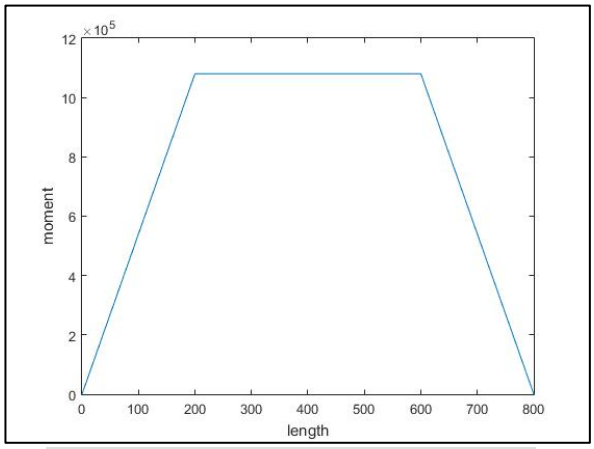


Fig 4.18 BMD of Lower bed

Specify the inertia of the selected beam in mm^4:	533333.33 mm^4
Specify the height of the section in mm:	40 mm
The calculated maximum stress in the beam is:	40.50 N/mm^2

Maximum alternating stress diagram

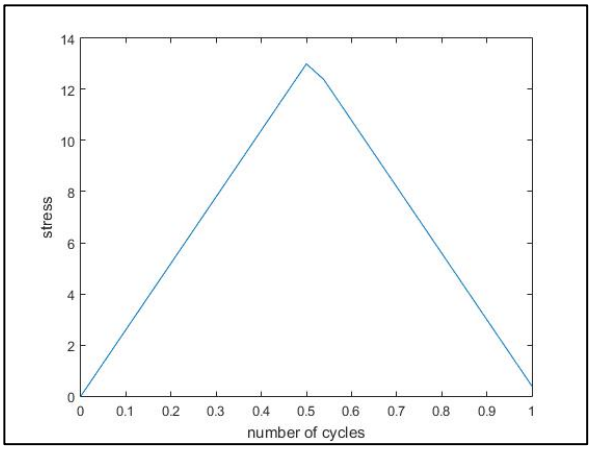


Fig 4.19 ASD of Lower bed

Judgement

The design lies within the Soderberg line and design is safe for infinite number of cycles.

4.13 TOP BED

Material of bed			=	AISI 1010
Length between centers	=	l	=	800mm
Thickness of bed	=	t	=	40mm
Width of bed	=	w	=	80mm
Inertia of bed	=	I	=	1/12*w*t^3
		I	=	1/12*80*40^3
		I	=	426666.67 mm^4
Force on the beam	=	F	=	10800 N
Distance of application of force	=	D	=	400 mm

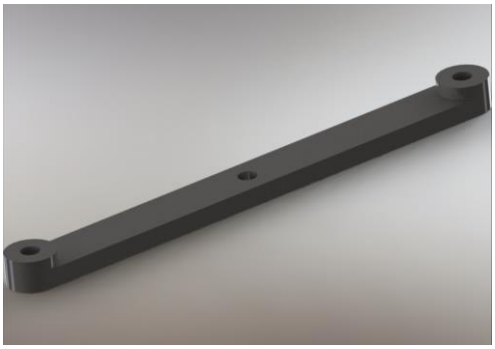


Fig 4.20 Rendered image of top bed

MATLAB COMMAND WINDOW

Specify material (AISI 1010 or AISI 1040):	AISI 1010
Specify type of loading (bending load, shearing load or axial load):	Bending load
Specify the part on which load is being applied (column, beam or bolt):	Beam
The calculated endurance limit is:	193.05 N/mm^2
The actual calculated endurance stress for beam is:	173.75 N/mm^2
Specify the length of the beam in mm:	800 mm
Specify the number of forces acting on the beam (one,two or three):	one
Specify the magnitude of force in Newton:	10800 N
Specify the distance of application of the force in mm:	400 mm
The calculated maximum moment is:	2160000.00 N/mm
The calculated section modulus is:	18648.02 mm^3

bending moment diagram

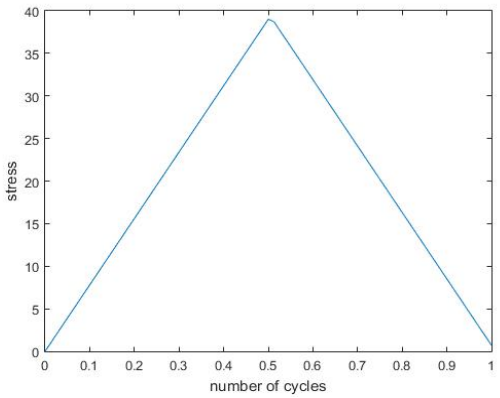


Fig 4.21 BMD of Top bed

Specify the inertia of the selected beam in mm^4:	426666.67 mm^4
Specify the height of the section in mm:	40 mm
The calculated maximum stress in the beam is:	101.25 N/mm^2

Maximum alternating stress diagram

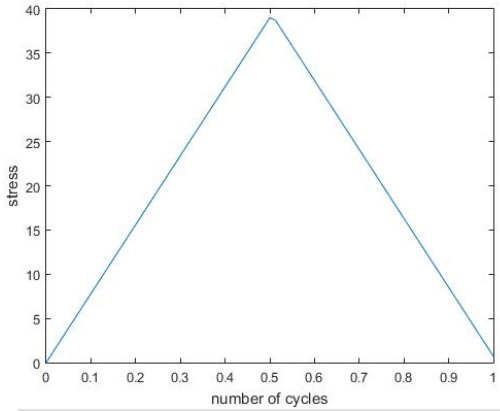


Fig 4.22 ASD of Top bed

Judgement

The design lies within the Soderberg line and design is safe for infinite number of cycles.

4.14 COLUMN

Material selection for column	=	AISI 1040
Diameter of column	=	48mm
Length of column	=	1400mm
Cross-sectional area	=	Pi/4 *D^2
	=	1809.55 mm^2
Inertia	=	(Pi*D^4)/32
	=	(Pi*48^4)/32
	=	521152.522mm^4
Axial force exerted on each column	=	5400N (accounting 20% for losses)

Fig 4.23 Rendered image of column

Command Window

Specify material (AISI 1010 or AISI 1040):	AISI 1040
Specify the type of loading i.e. bending load, shearing load or axial load:	Axial Load
Specify the part on which load is being applied (column, beam or bolt):	Column
The calculated endurance limit is:	310.00 N/mm^2
The actual endurance stress for beam is:	223.20 N/mm^2
Specify the nature of axial force (tensile or compressive):	Tensile
Specify cross-sectional area of the column in mm^2:	1809.55 mm^2
Specify the length of the column in mm:	1400 mm
Specify the force acting on the column in Newton:	5400 N
The calculated nominal tensile stress acting on the column is:	2.98 N/mm^2

Judgement

The design lies within the Soderberg line and design is safe for infinite number of cycles.

4.15 FORK OF COTTER KNUCKLE JOINT

Material of fork	AISI 1010
Material of Pin	K100 hardened
Minimum diameter of the shaft as specified by matlab and ansys:	20 mm
Factor of safety	1.5
Designed diameter of shaft	30mm

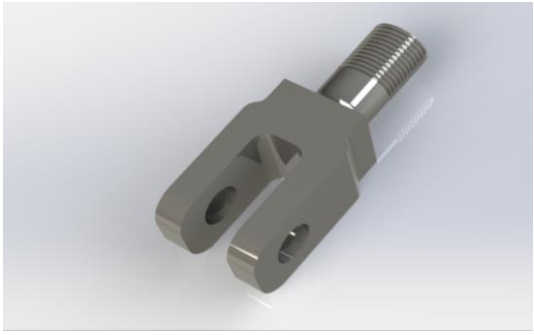


Fig 4.24 Rendered image of Knuckle joint

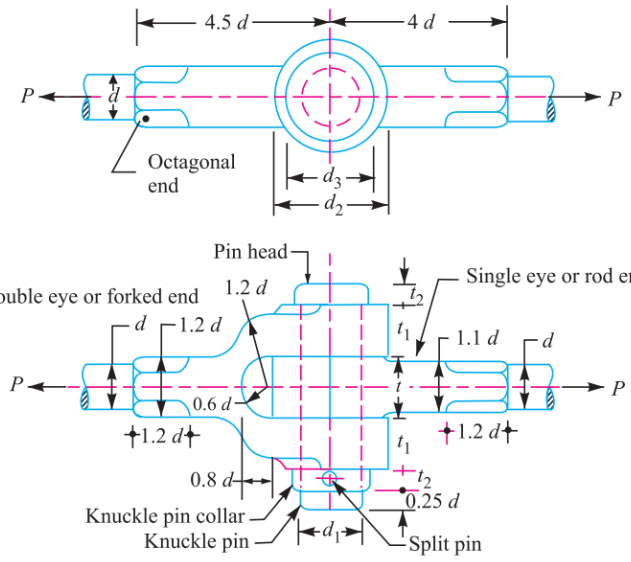


Fig 4.25 standards of designing knuckle joints as prescribed by Khurmi and Gupta 14th ed [21]

Following the standards of Knuckle joint as specified in Machine Design by Khurmi and Gupta 14th edition

Design of Fork and Pin

Diameter of pin	=	d_1	=	d	=	30 mm
Outer diameter of eye	=	d_2	=	2d	=	60mm
Diameter of knuckle pin head and collar	=	d_3	=	1.5d	=	45mm
Thickness of fork	=	t_1	=	0.75d	=	22.5 mm

4.16 CONNECTING ROD

Material of rod			=	AISI 1010
Length of connecting rod	=	l	=	330 mm
Thickness of connecting rod	=	t	=	35 mm
Depth of connecting rod	=	d	=	50 mm
Area of rectangular portion	=	A	=	d*t
		A	=	1750 mm^2
Inertia	=	I	=	1/12*d*t^3
		I	=	178645.833 mm^4

Fig 4.26 Rendered image of connecting rod

4.16.1 THICKNESS OF BUSHINGS

Radial force exerted	=	F	=	10800 N
Radius of smaller bush	=	r	=	23.5 mm
Area of smaller bush	=	A	=	pi*r^2
		A	=	1734.944mm^2
Pressure exerted in the bush	=	P	=	F/A
		P	=	10800/1734.944
		P	=	6.225 N/mm^2
Yield stress of AISI 1010	=	σ	=	296.474 N/mm^2
Factor of safety	=	F.O.S	=	2
Allowable stess	=	σ_{allow}	=	σ/F.O.S

		σ_{allow}	=	148.237 N/mm^2
Pressure vessel thickness formula	=	σ	=	p*r/(t_{min})
Minimum Thickness	=	t_{min}	=	P*r/(σ_{allow})
			=	6.225*23.5/(148.237)
		t_{min}	=	0.98mm

Judgement

selecting thickness = t = 10 mm

This thickness is applicable for all hollow parts such as flange couplings and bushings.

4.16.2 EVALUATION OF BUCKLING OF CONNECTING ROD

Command Window

Specify material (AISI 1010 or AISI 1040):	AISI 1040
Specify the type of loading (bending load, shearing load or axial load):	Axial Load
Specify the part on which load is being applied on (column, beam or bolt)	Column
The calculated endurance limit is:	193.05 N/mm^2
The actual endurance stress for beam is:	139.00 N/mm^2
Specify the nature of axial force (tensile or compressive)?	Compressive
Specify the cross-sectional area of the column in mm^2:	1750 mm^2
Specify the length of the column in mm:	330 mm
Specify the inertia of the column in mm^4:	17864.833 mm^4
The calculated critical load is:	226633.88 N

Judgement

The applied load is 10800N which is lesser than the critical load so the column will not buckle.

4.17 CONNECTING ROD LINKAGE: 70MM DIA SLIDING SHAFT

Material of shaft			=	AISI 1010
Diameter of shaft	=	d	=	70 mm
Length of shaft	=	l	=	338 mm
Area	=	A	=	Pi/4* d^2
		A	=	3848.45 mm^2
Inertia	=	I	=	(Pi*D^4)/32
		I	=	2357176.238 mm^4
Force on shaft	=	F	=	10800 N

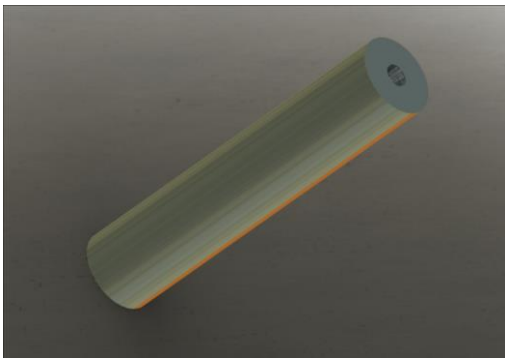


Fig 4.27 Rendered image of Mechanism link

4.17.1 EVALUATION OF BUCKLING

Command Window

Specify material (AISI 1010 or AISI 1040):	AISI 1040
Specify the type of loading (bending load, shearing load or axial load):	Axial Load
Specify the part on which load is being applied on (column, beam or bolt:	Column
The calculated endurance limit is:	193.05 N/mm^2
The actual endurance stress for beam is:	139.00 N/mm^2
Specify the nature of axial force (tensile or compressive)?	Compressive
Specify the cross-sectional area of the column in mm^2:	3848.45 mm
Enter the length of the column in mm:	338 mm
Specify the inertia of the column in mm^4:	2357176.238 mm^4
The calculated critical load is:	528151.56 N

Judgement

The applied load is 10800N which is lesser than the critical load so the column will not buckle

4.18 ADJUSTABLE CRANKSHAFT

The crankshaft of the machine comprises of two components that can be evaluated for stress:

- The connecting rod pin
- The lead screw

This unit rotates at a high speed of 120rpm and all the load of the struts is acting on it. So the design validation of this part is of paramount importance.

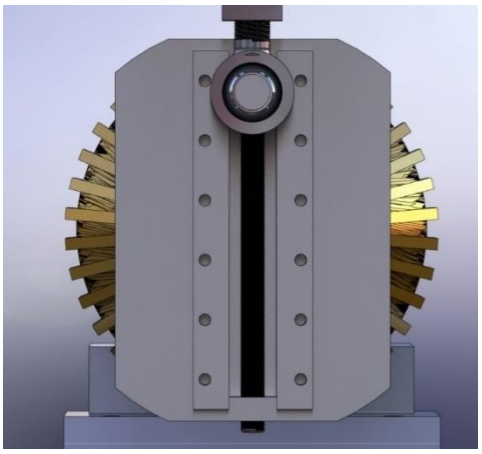


Fig 4.28 Rendered image of Adjustable Crankshaft

4.18.1 CONNECTING ROD PIN

Material of pin			=	AISI 1040
Diameter of pin	=	d		30 mm
Length of pin	=	l		80 mm
Area of pin	=	A	=	Pi/4*D^2
		A	=	Pi/4 *30^2
		A	=	706.858 mm^2
Inertia of pin	=	I	=	(Pi*D^4)/32
		I	=	79521.56 mm^4
Distance of application of force from pin support			=	70 mm

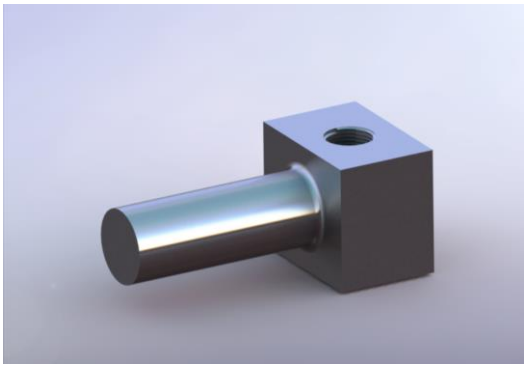


Fig 4.29 Rendered image of connecting rod pin

We can assume that the pin is behaving like a cantilever beam in the presence of the force and we can evaluate the bending stresses.

MATLAB COMMAND WINDOW

Specify material (AISI 1010 or AISI 1040):	AISI 1040
Specify the type of loading (bending load, shearing load or axial load):	Bending load
Specify the part on which load is being applied on (column, beam or bolt)	Beam
The calculated endurance limit is:	310.00 N/mm^2
The actual endurance stress for beam is:	279.00 N/mm^2
What is the length of the beam in mm:	80
Specify the number of forces acting on the beam (one,two or three?):	One
What is the magnitude of first force in Newton:	10800 N
Specify the distance of application of the force in mm:	70 mm
The calculated maximum moment is:	94500.00 N/mm
The calculated section modulus is:	508.06 mm^3

bending moment diagram

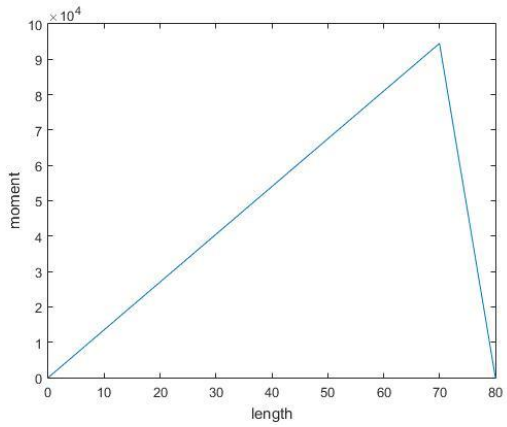


Fig 4.30 BMD of connecting rod pin

Specify the inertia of the selected beam in mm^4:	79521.56 mm^4
Specify the height of the section in mm:	30 mm
The calculated maximum stress in the beam is:	17.83 N/mm^2

Maximum alternating stress diagram

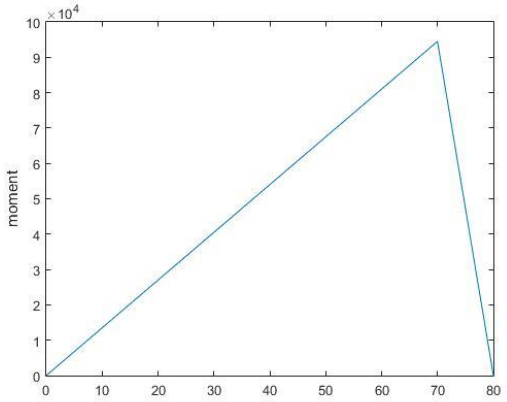


Fig 4.31 ASD of connecting rod pin

Judgement

The design lies within the Soderberg line and design is safe for infinite number of cycles.

4.18.2 LEAD SCREW

Material	=	AISI 1010
Diameter	=	20 mm
Length	=	320 mm
Pitch	=	1.5 mm
Major Dia	=	20 mm
Minor dia	=	18.160 mm
Depth of thread	=	0.920 mm
Stress area	=	272 mm^2

Fig 4.32 Rendered image of lead screw

MATLAB COMMAND WINDOW

Specify material (AISI 1010 or AISI 1040):	AISI 1040
Specify the type of loading (bending load, shearing load or axial load):	Axial load
Specify the part on which load is being applied on (column, beam or bolt)	Bolt
The calculated endurance limit is:	193.05 N/mm^2
The actual endurance stress for bolt is:	154.44 N/mm^2
Specify the force acting on the bolt in Newton:	10800 N
Specify the number of bolts:	1
The calculated minimum diameter of the bolt is:	9.44 mm
Specify the major diameter of the selected bolt:	20 mm
Specify the minor diameter of the selected bolt:	18.026 mm
Specify the pitch of the selected bolt:	1.5 mm
Specify the depth of thread of the selected bolt:	0.920 mm
Specify the Stress area for the selected bolt:	272 mm^2
The calculated thread angle for the bolt is:	78.38 degrees
The calculated maximum stress occurring in the bolt is:	39.71 N/mm^2

Maximum stress diagram

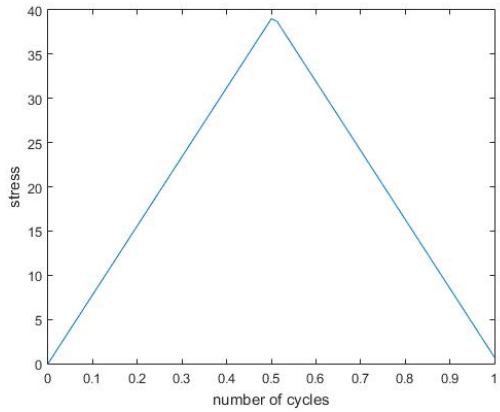


Fig 4.33 ASD of lead screw

Judgement:

The design lies within the Soderberg line and design is safe for infinite number of cycles.

This calculation also verifies the M30 lead screw mounted on top of the middle bed.

Also, the minimum diameter calculated for bolts is 9.44mm ≅ 10mm hence, 10mm is the base diameter for bolts in the machine

4.19 BEARING SELECTION:

S.NO	Bearing type	Outer Diameter	Application	Inner Diameter	Depth	Basic dynamic load rating	Manufacturer
1	2306 Self aligning bearing	72mm	Connecting rod	30mm	27mm	21.375 KN	IKO BEARINGS
2	NA 6906 Needle roller bearing	47mm	Knuckle joint	30mm	30mm	34.1 KN	IKO BEARINGS
3	Single row ball bearing	37mm	Crankshaft	12mm	12mm	15.5KN	IKO BEARINGS
4	Thrust bearing	37mm	Crankshaft	20mm	20mm	17.63K	IKO BEARINGS

Table 4.4 Final selection of beams [27]

Judgement:

Since the dynamic load rating of all the bearings is greater than 10800N. Hence, these bearings are adequate for our use.

CHAP 5

5) MACHINE DRAWINGS

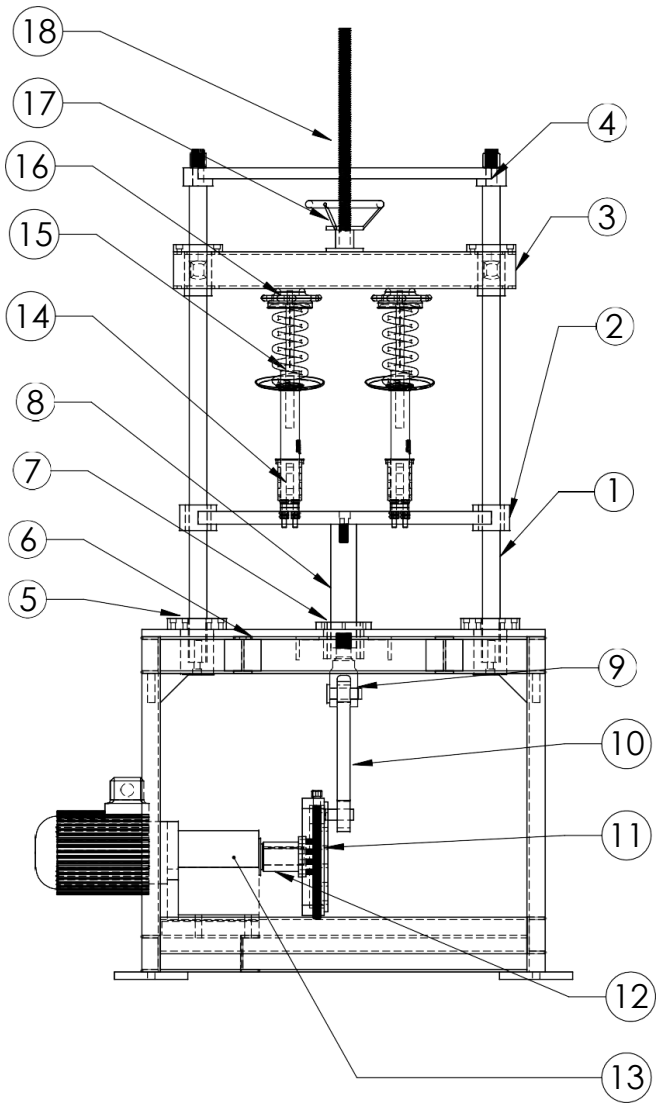
5.1 SOFTWARE

The designing of this equipment is done on the following softwares:

- Solidworks
- Autocad

5.2 DESIGN OF STRUCTURAL BEAM AND MECHANISM

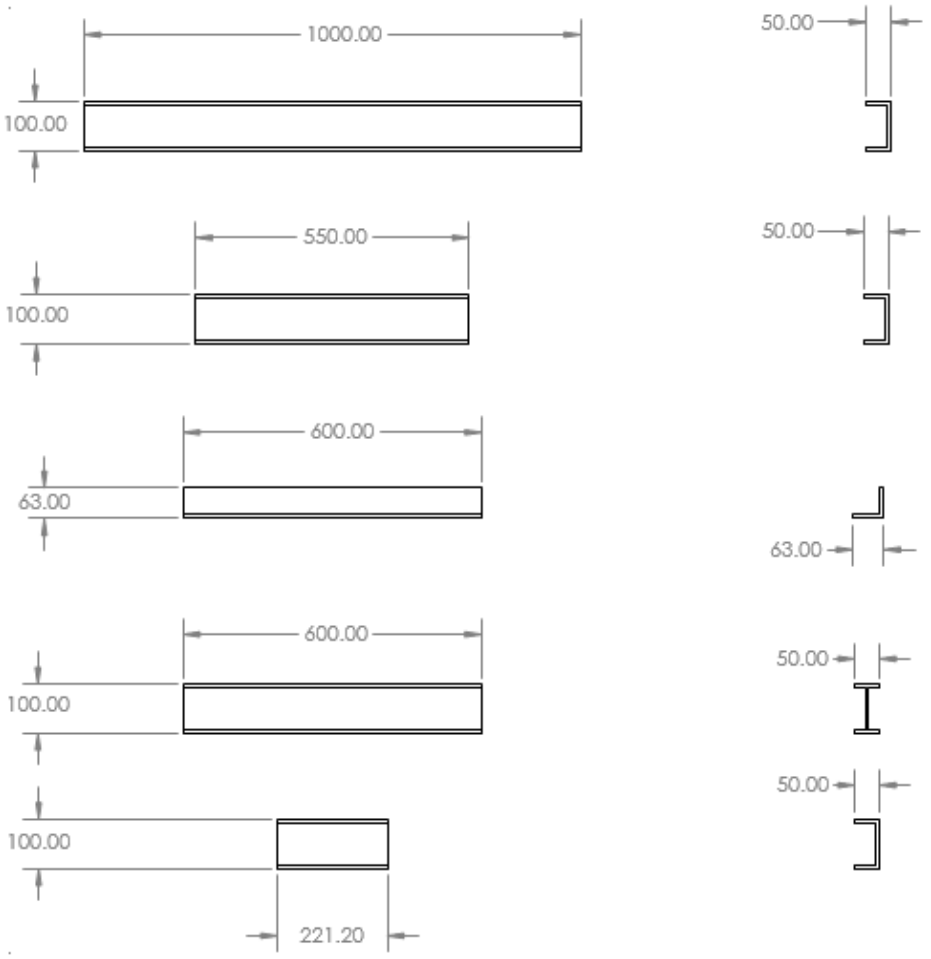
5.2.1 DESIGN ANNOTATION



S.NO	PART
1	COLUMN
2	LOWER BED
3	MIDDLE BED
4	TOP BED
5	COLUMN BUSHING
6	LOWER BASE
7	LOWER BRONZE BUSHING
8	MECHNANISM LINKAGE SHAFT
9	KNUCKLE JOINT
10	CONNECTING ROD
11	CRANK SHAFT
12	FLANGE COUPLING
13	10HP MOTOR
14	LOWER FIXTURE
15	STRUT
16	UPPER FIXTURE
17	HANDLE
18	BALL SCREW BOLT

Fig 5.1 Design annotation of machine assembly

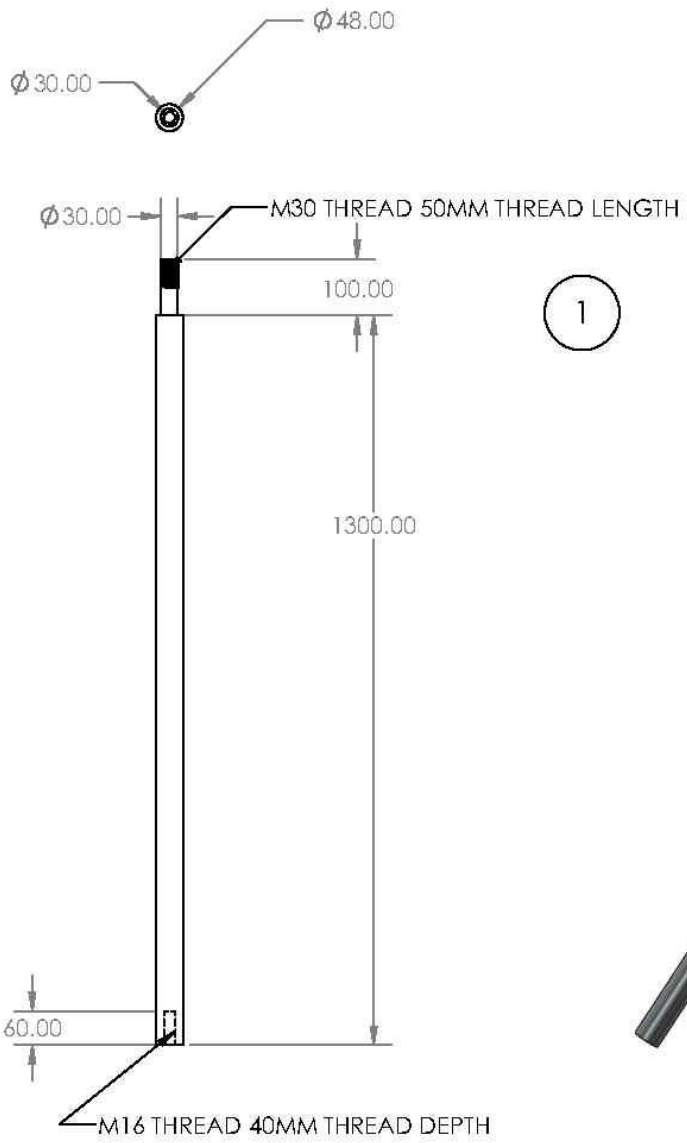
5.2.2 STRUCTURAL BEAMS



S.NO	PART	DIMENSION	QUANTITY
1	C-SECTION	1010mm	4
2	C-SECTION	560mm	5
3	ANGLED SECTION	610mm	2
4	I-SECTION	610mm	2
5	C-SECTION	235mm	2

Table 5.1 Bill of materials for structural beams

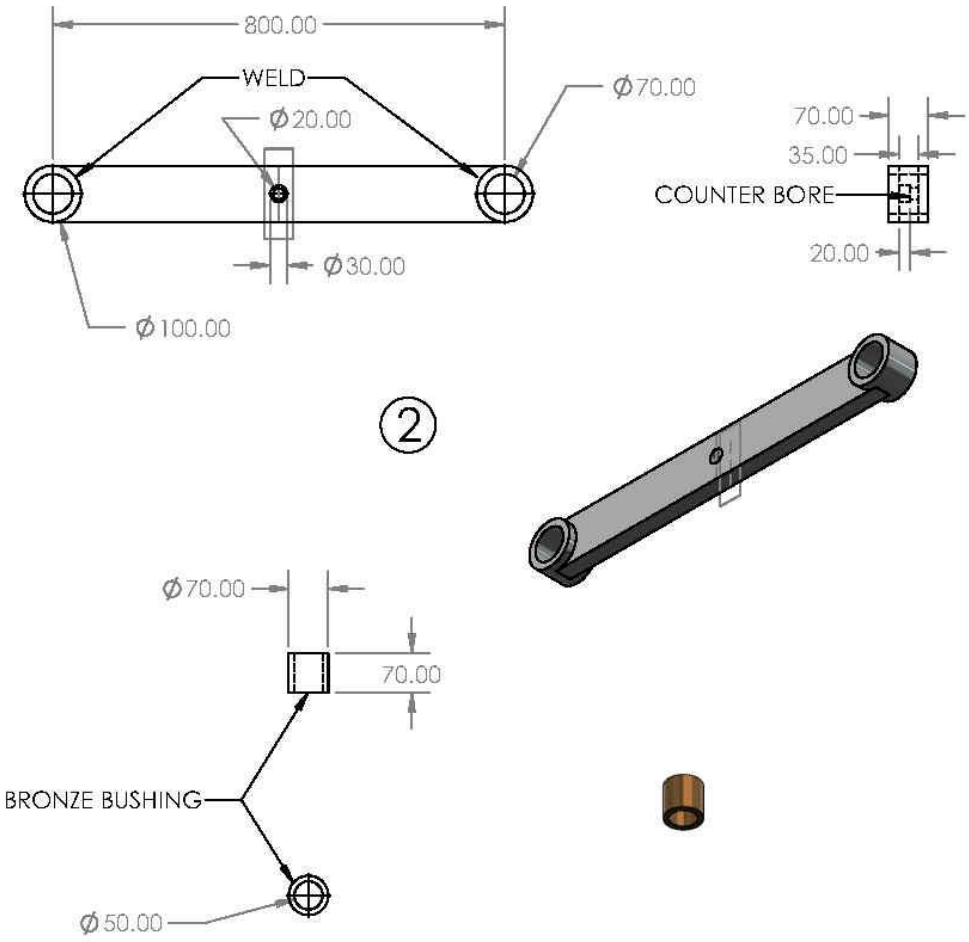
5.2.3 COLUMNS



S.NO	PART	MATERIAL	QUANTITY
1	SHAFT	AISI 1040	2

Table 5.2 Bill of materials for columns

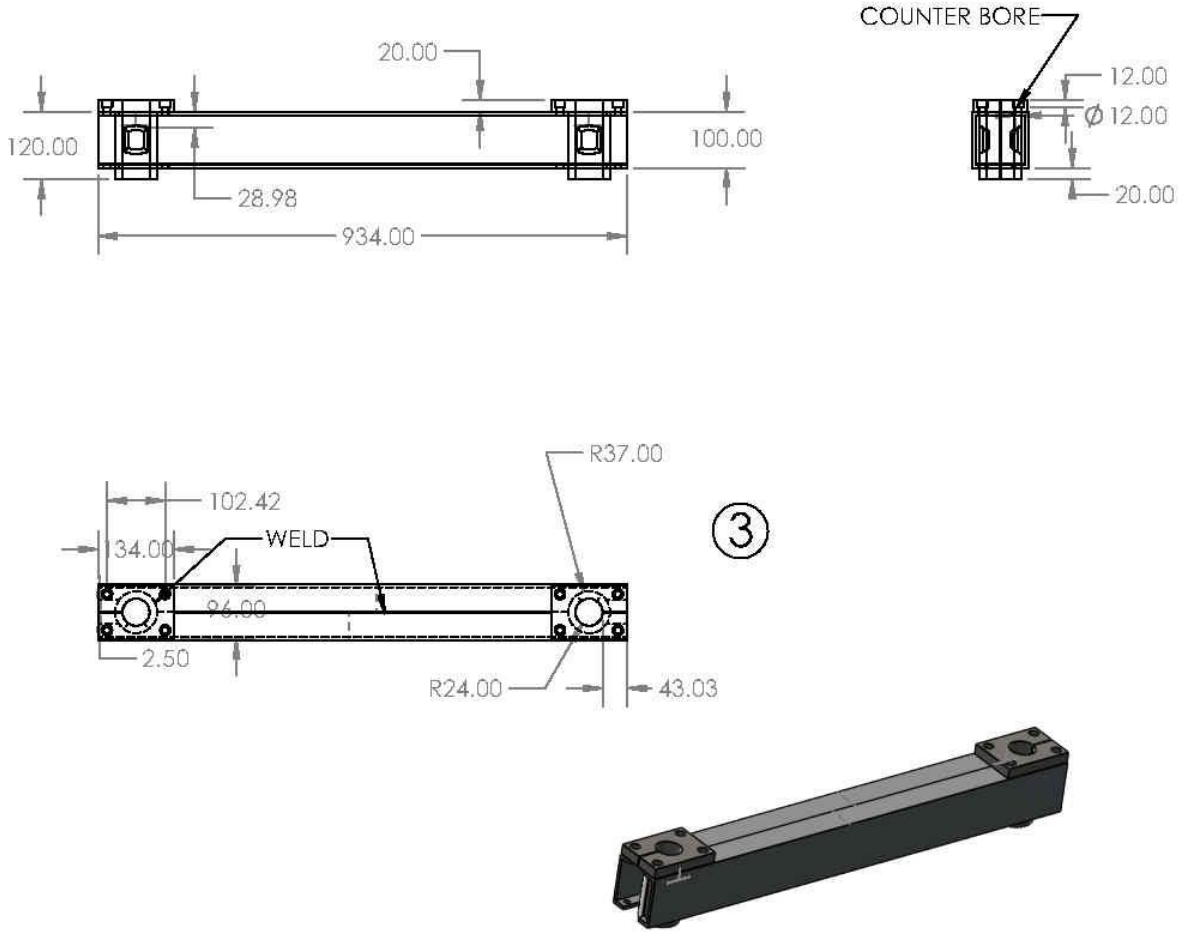
5.2.4 LOWER BED



S.NO	PART	DIMENSIONS	MATERIAL	QUANTITY
1	PLATE	35mm*100mm*800 mm	AISI 1010	1
2	BUSH	OD 100 ID 70	AISI 1010	2
3	BUSH	OD 70 ID 48	BRONZE	2

Table 5.3 Bill of materials for lower bed

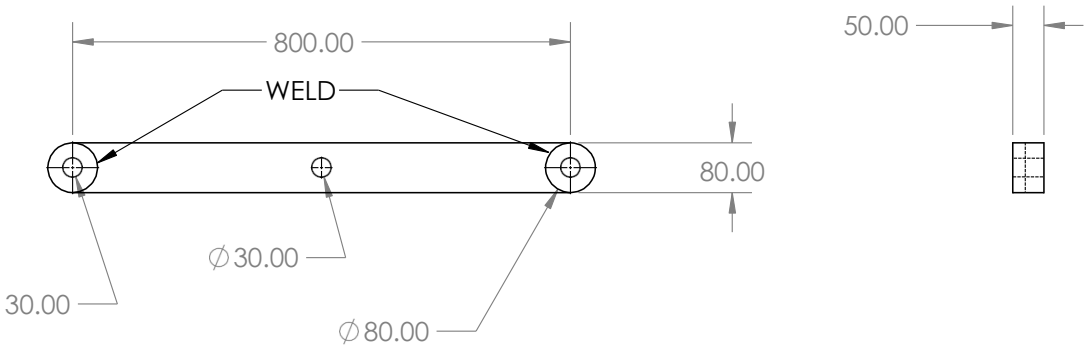
5.2.5 MIDDLE BED

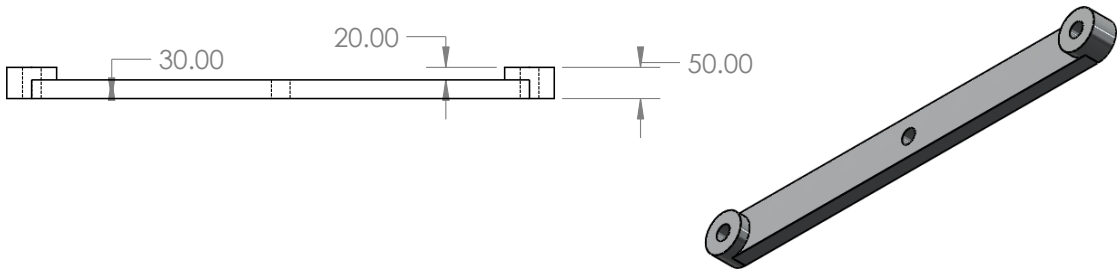


S.NO	PART	MATERIAL	DIMENSIONS	QUANTITY
1	C-SECTION	-	1000mm	2
2	BUSH	AISI 1010	ID 48mm OD 74mm	2
3	PLATE	AISI 1010	140mm*100mm	2
4	BOLT	GRADE 12.9	M12	8
5	NUT		M12	8

Table 5.4 Bill of materials for middle bed

5.2.6 TOP BED

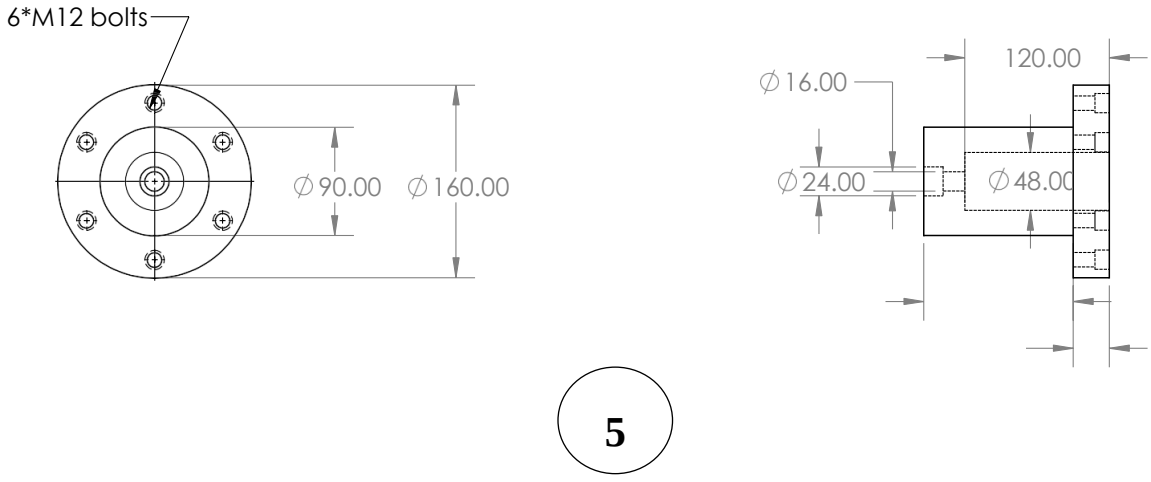


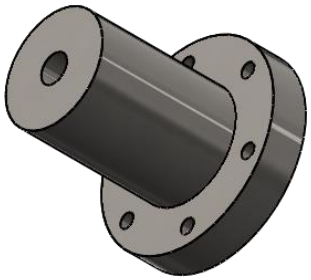


S.NO	PART	MATERIAL	DIMENSION	QUANTITY
1	PLATE	AISI 1010	80mm*30mm*800 mm	1
2	BUSH	AISI 1010	OD 80mm ID 30mm	2

Table 5.5 Bill of materials for top bed

5.2.7 COLUMN BUSHING

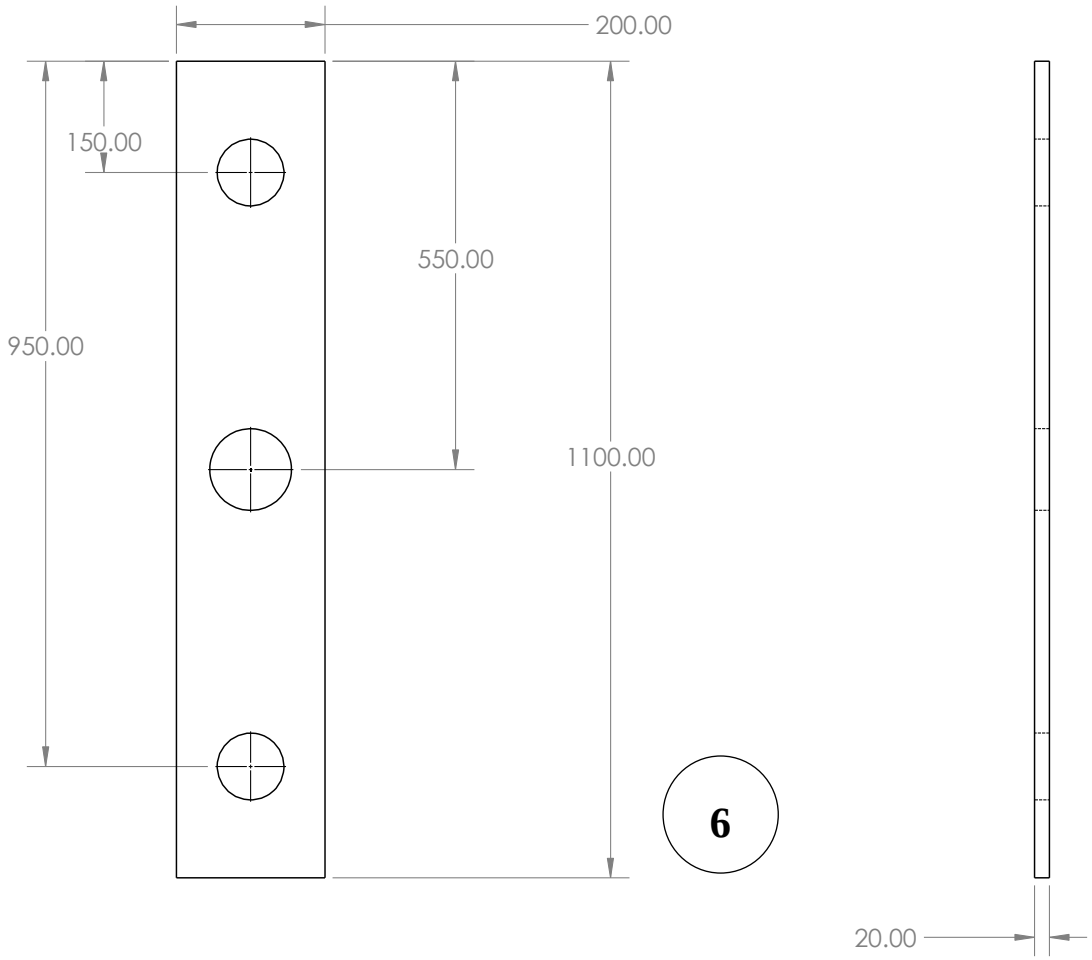


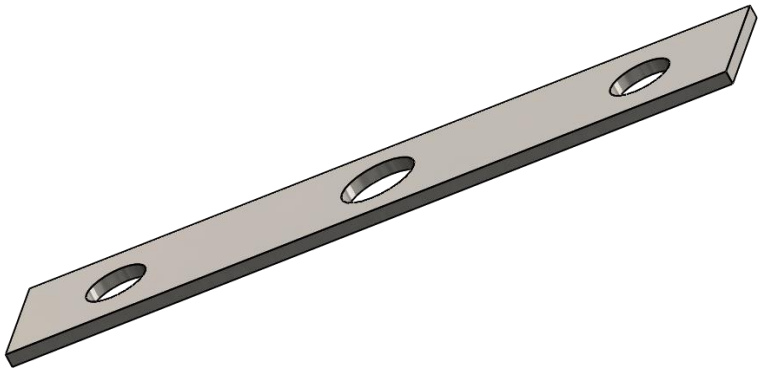


S.NO	PART	MATERIAL	DIMENSION	QUANTITY
1	BUSH	AISI 1010	160mm dia 160mm length	2
2	M12 BOLTS	GRADE 12.9	70mm	12
3	M16 BOLTS	GRADE 12.9	75mm	2

Table 5.6 Bill of materials for column bushing

5.2.8 LOWER BASE

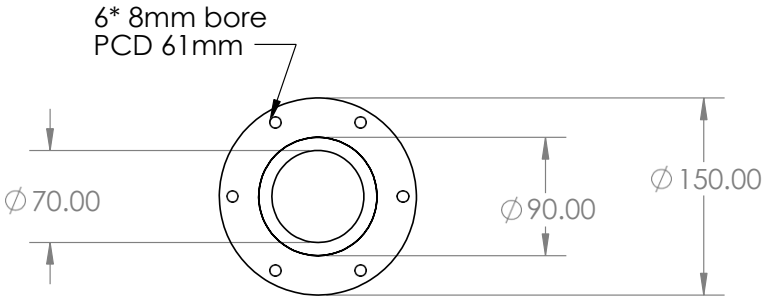


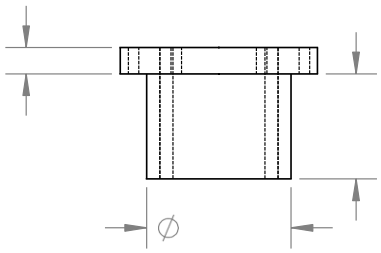


S.NO	PART	MATERIAL	DIMENSION	QUANTITY
1	PLATE	AISI 1010	1100mm*20mm* 200mm	1

Table 5.7 Bill of materials for lower base

5.2.9 LOWER BRONZE BUSH WITH COLLAR





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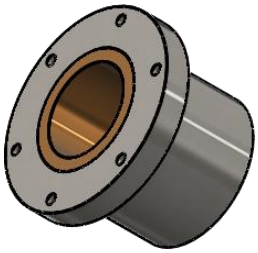
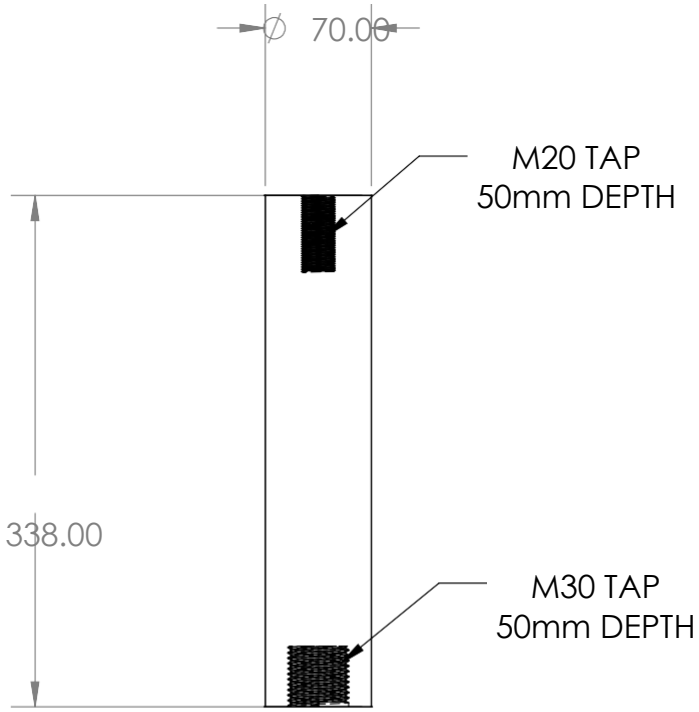


S.NO	PART	MATERIAL	DIMENSION	QUANTITY
1	BUSHING	AISI 1010	OD 150mm ID 90mm	1
2	BUSHING	BRONZE	OD 9mm ID 70mm	2
3	M8 BOLTS	GRADE 12.9	40MM	6

Table 5.8 Bill of materials for lower bronze with collar

5.2.10 MECHANISM LINKAGE SHAFT



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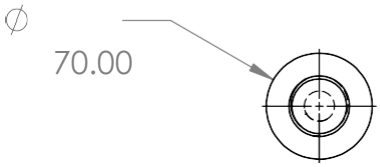
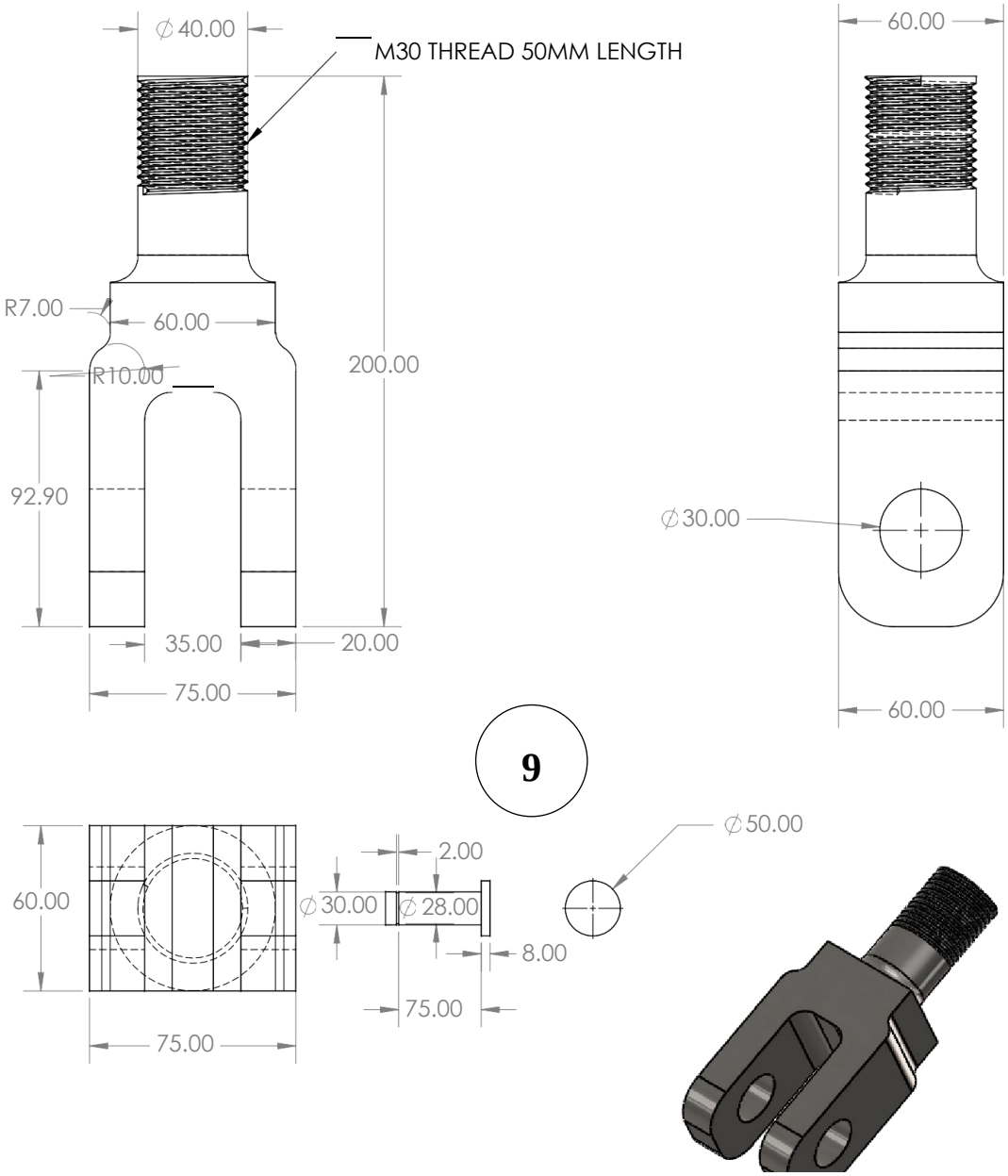


S.NO	PART	MATERIAL	DIMENSION	QUANTITY
1	SHAFT	AISI 1010	70MM DIA 340MM LENGTH	1

Table 5.9 Bill of materials for mechanism linkage shaft

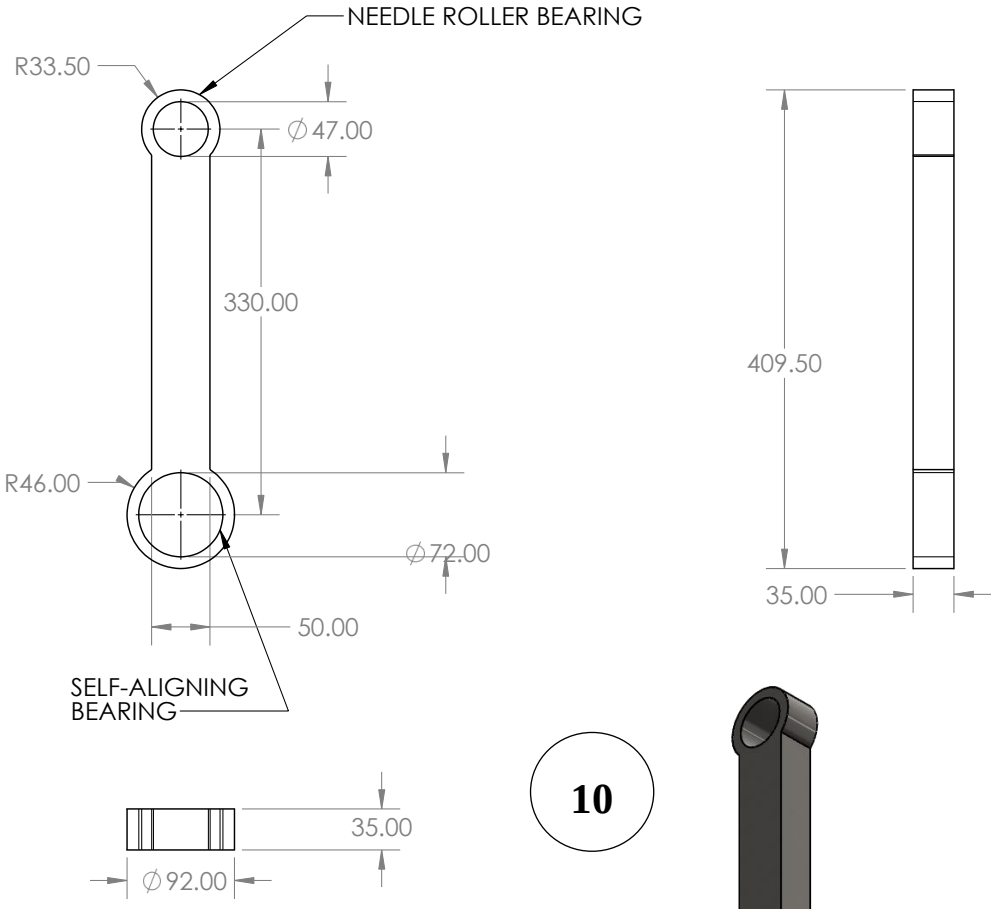
5.2.11 KNUCKLE DRAWING

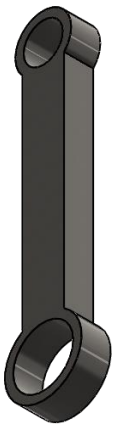


S.NO	PART	MATERIAL	DIMENSION	QUANTITY
1	PLATE	AISI 1010	75mm*60mm*200 mm	1
2	SHAFT	K100	50mm dia 85mm length	1
3	RETAINER		30mm dia 2mm thickness	1

Table 5.10 Bill of materials for Knuckle joint

5.2.12 CONNECTING ROD



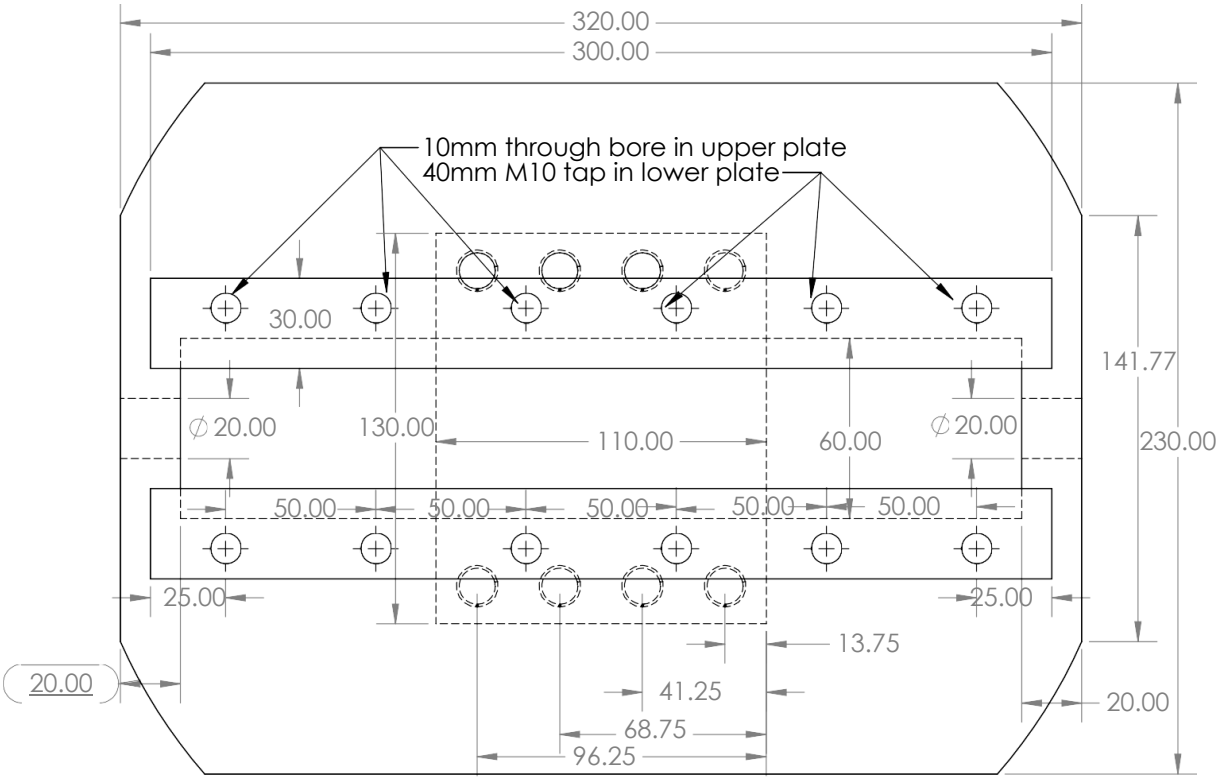


S.NO	PART	MATERIAL	DIMENSION	QUANTITY
1	PLATE	AISI 1010	50mm*30m*330mm	1
2	BUSHING	AISI 1010	OD 92mm ID 72mm	1
3	BUSHING	AISI 1010	OD 67mm ID 47mm	1
4	2306 SELF-ALIGNING BEARING	-	OD 72mm ID 30mm	1
5	NA 6906 NEEDLE ROLLER BEARING	-	OD 47mm ID 30mm	1

Table 5.11 Bill of materials for connecting rod

5.2.13 CRANKSHAFT

HOUSING



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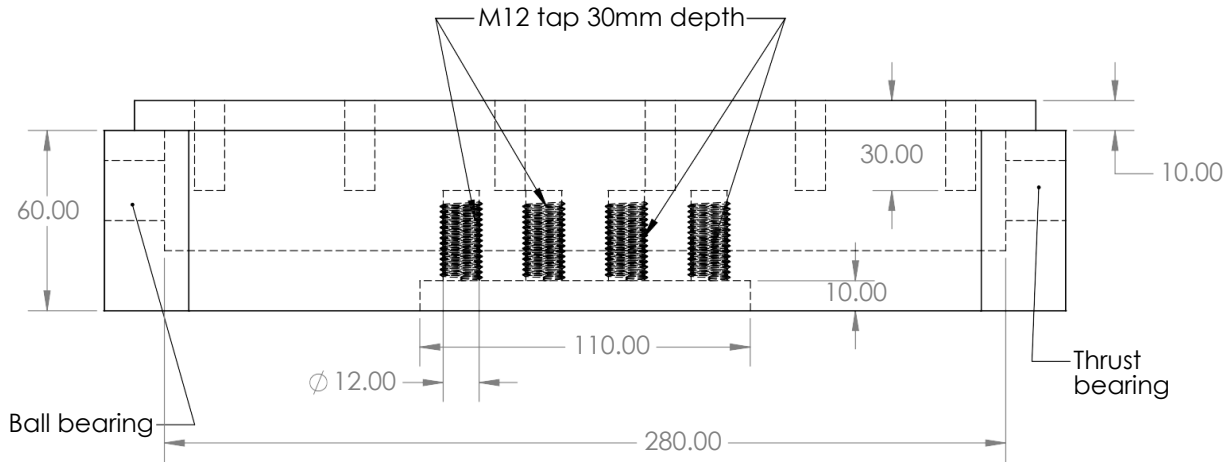
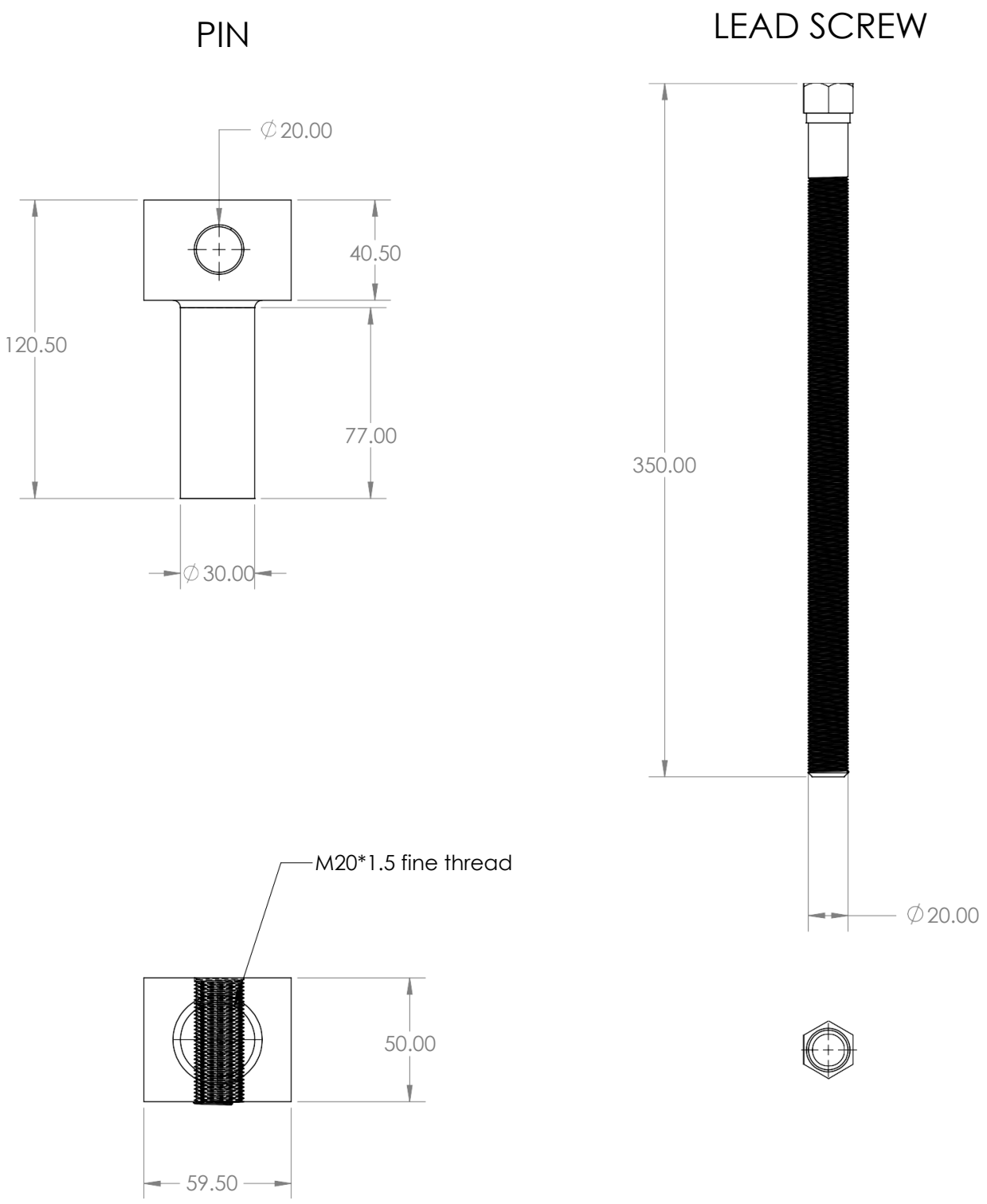


PIN AND LEAD SCREW

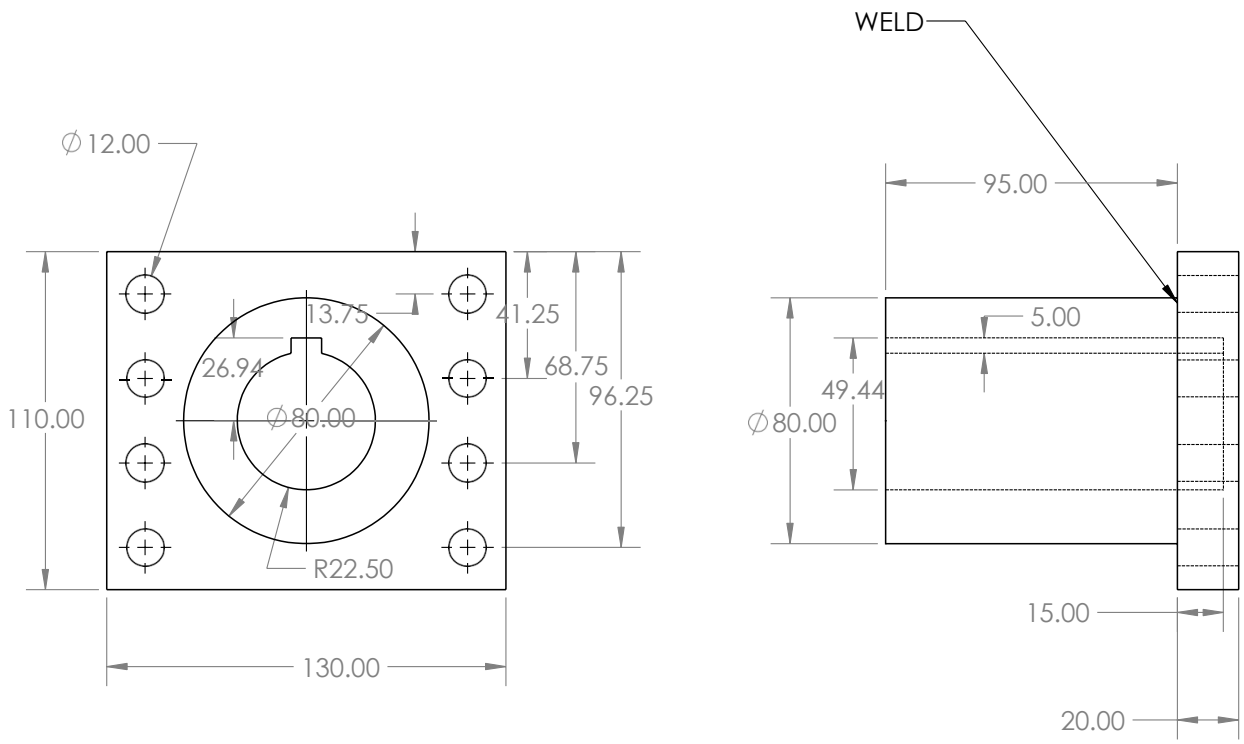


MATERIAL REQUIREMENT FOR CRANKSHAFT

S.NO	PART	MATERIAL	DIMENSION	QUANTITY
1	PLATE	AISI 1010	320mm*230mm* 60mm	1
2	PLATE	AISI 1010	30mm*20mm* 280mm	2
3	PLATE	AISI 1040	125mm*50mm*60 mm	1
3	M10 BOLT	GRADE 12.9	50mm length	12
4	M12 BOLT	GRADE 12.9	50mm length	8
5	M20 BOLT	CS	350mm	1
6	THRUST BEARING	-	ID 20mm OD 37mm	1
7	BALL BEARING	-	ID 12mm OD 37mm	1

Table 5.12 Bill of materials for crankshaft

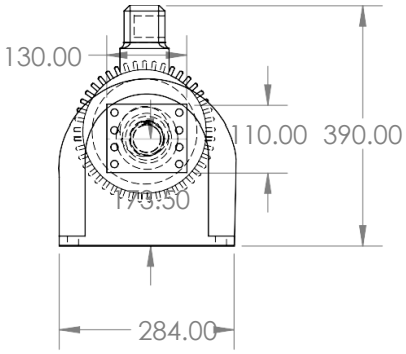
5.2.14 FLANGE COUPLING

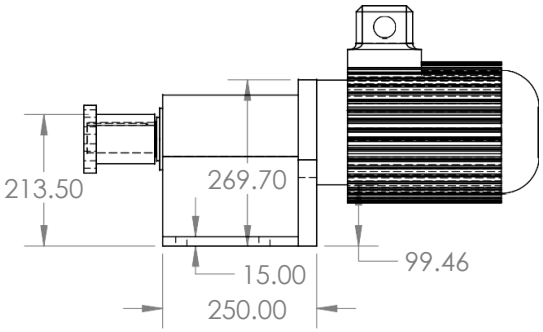


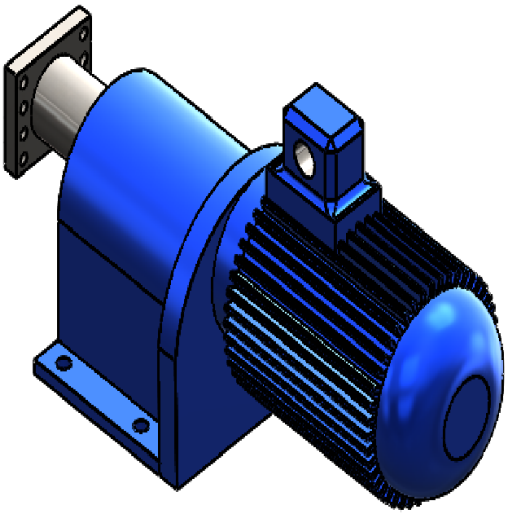
S.NO	PART	MATERIAL	DIMENSION	QUANTITY
1	BUSH	AISI 1010	OD 80mm ID 48mm length 100mm	1
2	PLATE	AISI 1010	130mm*110mm*20 mm	1

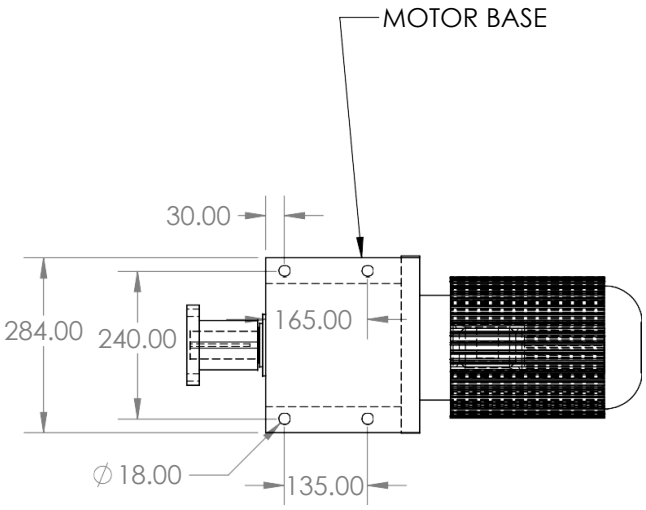
Table 5.13 Bill of materials for crankshaft

5.2.15 MOTOR FLANGE ASSEMBLY AND MOTOR BASE





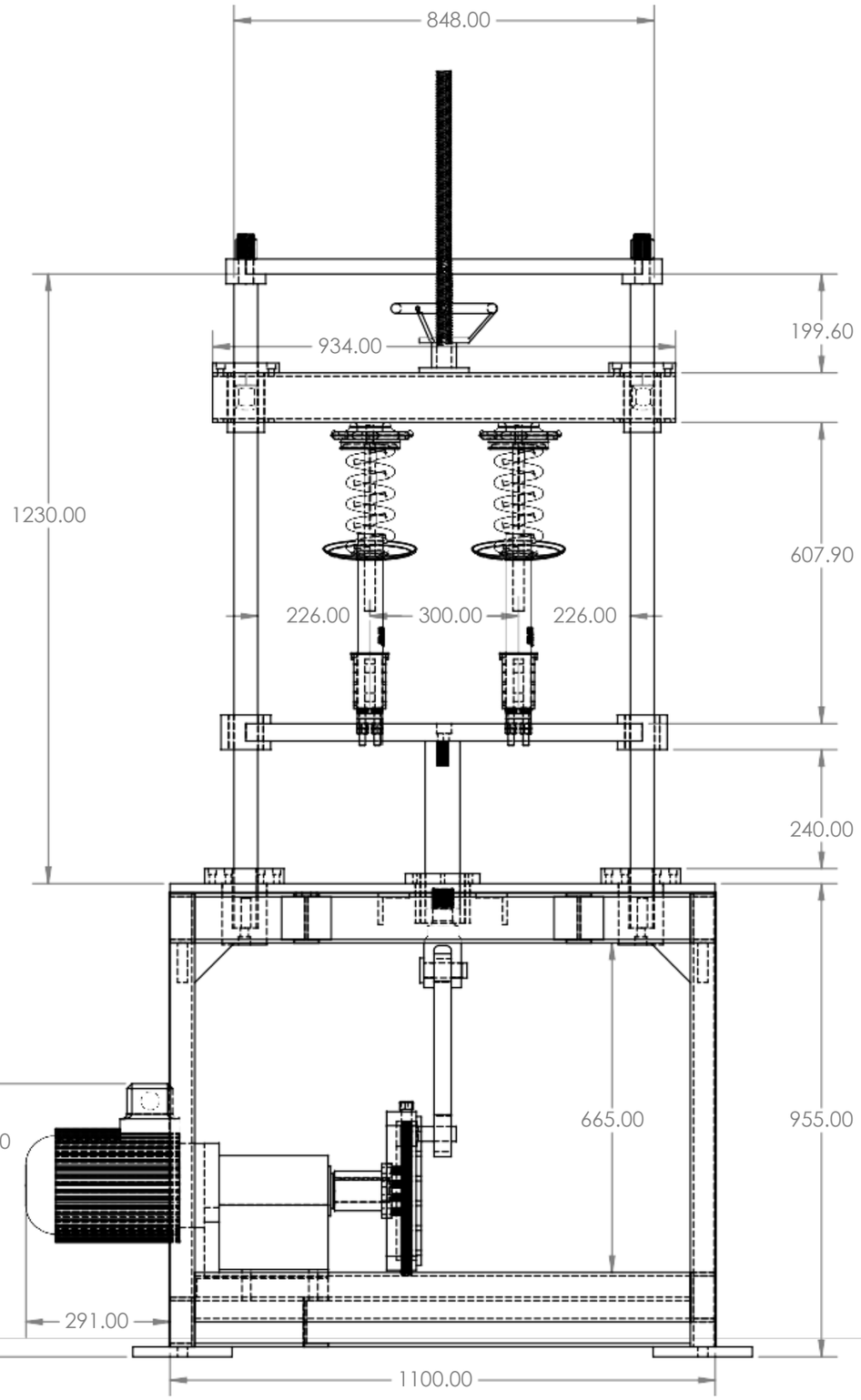


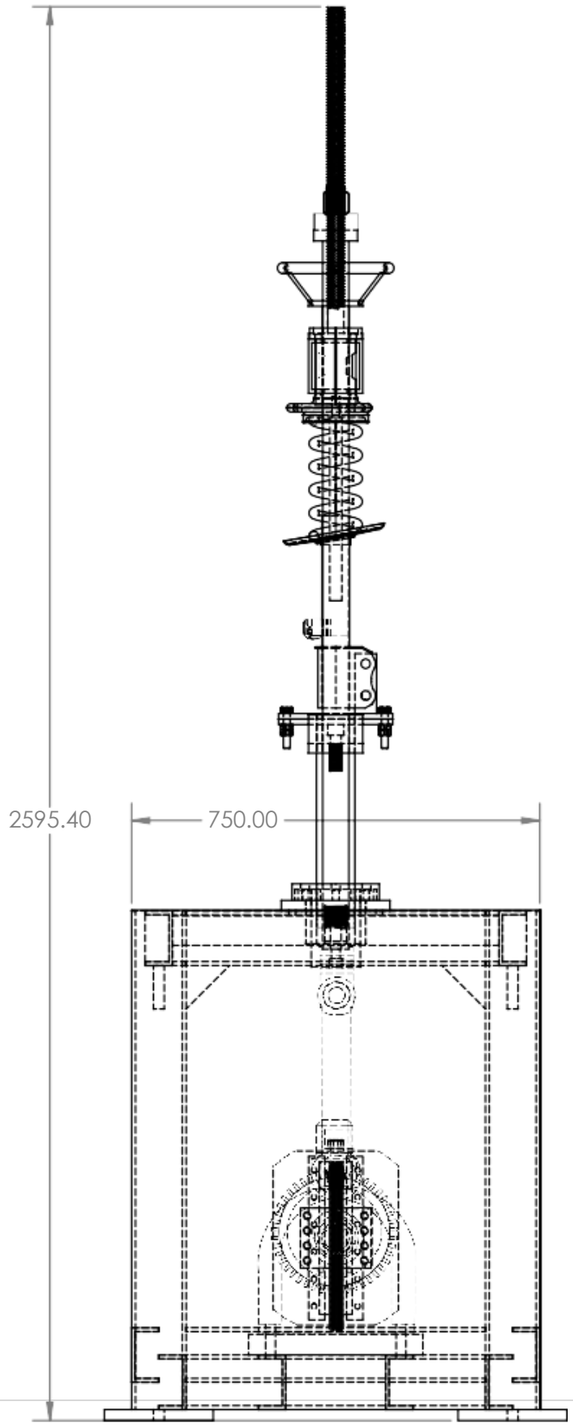


S.NO	PART	MATERIAL	DIMENSION	QUANTITY
1	10 HP MOTOR	-	-	1
2	PLATE	AISI 1010	250mm*300mm*38 mm	1
3	M16 BOLTS	GRADE 12.9	55mm	4

Table 5.14 Bill of materials for Motor flange assembly

5.3 ASSEMBLY DRAWING





5.4 RENDERED VIEW

Fig 5.2 Rendered image of machine

CHAPTER 6:

6) FABRICATION:

Fabrication refers to the actual development of machine. This includes procurement of raw materials, components and hardware, manufacturing of parts of machine and then assembling all manufactured parts and standard parts to form machine.

6.1 PROCUREMENT

Procurement means obtaining goods and services. In our project we purchased the Mechanical and Electrical components, Hardware and raw materials through AIL's official purchasing partner RELIANCE TRADING CO. some of the materials and electrical components were obtained from inventory of AIL.

6.1.1 STANDARD PROCEDURE OF PROCUREMENT AT AIL:

1. Obtaining quotation from Goods/Service provider.
2. Making of Purchase requisition using SAP software.
3. Approval from Manager of department and HOD.
4. Submission of PR to finance department.
5. Purchasing of Goods and delivery to Storeroom/ inventory.
6. Making Material Transfer Note (MTN) using SAP to obtain Goods from Inventory.
7. Shifting of goods to respective department.

6.2 BILL OF QUANTITY

6.2.1 BOQ OF STRUCTURE

SHEET#1

DURABILITY TESTING MACHINE FOR STRUTS

Structure

ITEM NO.	PART NUMBER	CROSS SECTION	LENGTH	FEATURES	MATERIAL	QTY.	PRICE PER UNIT	PRICE
1	I-beam	100*50	600mm	Welded ends	Mild Steel	2	1400	2800
2	metal rod	160mm dia	170mm		mild steel	2	6750	13500
3	Column	50mm dia	1200mm	Threaded both ends	AISI1141 with case hardening	2	10058	20116
4	Lower table	100mm*35mm	800mm	Ends welded to 50mm bore bushing	Mild Steel	1	10000	10000
5	Top bed	80mm*30mm	800mm	Ends welded to 30mm bushing	Mild Steel	1	6000	6000
6	Metal plate	200mm*20mm	1100mm	50mm bore in middle	Mild Steel	1	8000	8000

7	Metal shaft	50mm dia	500mm	M48 course threads on one end and weldment to M48 threaded bushing on the other end. Case hardened	Mild Steel	1	3465	3465
8	C-section	100mm*50mm*6mm	1300mm	End welds	Mild steel	4	3200	12800
9	C-section	100mm*50mm*6mm	915mm	End welds	Mild steel	4	2185	8740
10	C-section	100mm*50mm*6mm	550mm	End welds	Mild steel	4	1680	6720
11	Middle bed	100mm*100mm	1000mm	Two C-section welded together	Mild steel	1	6400	6400
12	Metal bar	86mm *44mm	100mm	Filled weld on one surface	Mild steel	4	1000	4000
13	Metal rib	80mm*80mm*20mm	-	Two surfaces fillet weld	Mild steel	8	1000	8000
14	Angled section	63mm*63mm*9mm	600mm	Ends welded	Mild Steel	2	1500	3000
15	Metal bar	100mm*10mm	160mm	50mm bore, M50 threaded course	Mild Steel	1	900	900

16	Metal bar	200mm*20mm	300mm	-	Mild Steel	4	4500	18000
17	Top sheet	750mm*2mm	1600mm	-	Mild Steel	1	7000	7000
18	Side sheet	750mm*2mm	915mm	-	Mild Steel	2	9000	18000
19	Front sheet	915mm*2mm	1600mm	-	Mild Steel	1	8750	8750
20	Lead screw wheel	300mm dia, 60mm thickness	-	-	Mild steel	1	10000	10000
21	Bushing	70mm OD, 48mm ID	70mm	-	Bronze	2	4572	9144
22	Mild steel bushing	48mm bore, 12mm wall thickness	100mm	Welded ends	Mild Steel	2	1200	2400
TOTAL AMMOUNT								**187735**

Table 6.1 BOQ of Structure

6.2.2 BOQ OF HARDWARE

SHEET#2								
DURABILITY TESTING MACHINE FOR STRUTS								
Hardware								
ITEM NO.	**PART NUMBER**	**CROSS SECTION**	**LENGTH**	**FEATURES**	**MATERIAL**	**QTY.**	**PRICE PER UNIT**	**PRICE**
1	lead screw	20mm dia	250mm		mild steel	1	2000	2000

2	Strut bolt Handle	-	-	-	-	1	7000	7000
3	Strut bolt	30mm dia	600mm	M30 threaded course	Mild steel	1	2000	2000
4	Nut	30mm dia	-	-	Mild steel	2	300	600
5	alan bolt	20mm dia	100mm		grade 8.8	2	100	200
6	Alan bolt	12mm dia	-	-	Grade 8.8	20	75	1500
7	Washer	-	-	-	-	55	10	550
8	Nut	12mm dia	-	-	-	54	12	648
9	Alan bolt	12mm dia	150mm	M12 course threads	Grade 8.8	14	75	1050
10	Alan bolt	10mm dia	20mm	M10 course threads	Grade 8.8	6	60	360
TOTAL AMMOUNT								**17908**

Table 6.2 BOQ of Hardware

6.2.3 BOQ OF ELECTRICAL

SHEET#3				
ELECTRICAL				
S. NO	PART NUMBER	QUATITY	SPECS	COST
1	Load Cell (Tension weight Module)	1	500kg	356000
2	Proximity sensor (U-type)	1	Omron	6200
3	Emergency Stop Button	1	Fuji	2460
4	VFD	1	10hp (Poma)	49800
5	Starter	1	Tele Mechanic	8000
6	Contractor	1	LC1-D50	11500
7	Mushroom Button	2	Fuji	1400
8	Panel	1	18-guage	4500
9	Wiring (Coils)	3	Copper	6700
10	C-Cones	1	Siemens	1000
11	Tower Lights for Display	1	Panasonic	4800
12	Emergency Stop Guard Master	1	Fuji	1200
13	Isolator switch (Loto)	1	Fuji	10000
14	HMI	1	FX10 (Profess)	38000
15	PLC	1	Mitsubishi	42000
16	Breaker	1	30 amp (Tetra)	5000
17	Push Buttons	2	Fuji	650

18	Selectors	1	Fuji	1260
19	Power Supply	1	5-amp	3200
		TOTAL AMOUNT		**233270**

Table 6.3 BOQ of Electrical

6.2.4 BOQ OF MECHANISM

SHEET#4							
DURABILITY TESTING MACHINE FOR STRUTS							
Equipment							
ITEM NO.	**PART NUMBER**	**CROSS SECTION**	**LENGTH**	**FEATURES**	**QTY.**	**PRICE PER UNIT**	**PRICE**
1	Needle roller bearing	(RNA 6905)	ID 30mm	STD	1	2570	1500
2	Thrust bearing	-	OD 37mm ID 20mm	STD	1	350	350
3	Ball bearing	-	OD 37mm ID 12mm	STD	1	450	450
4	Self Aligning bearing	(2306)	ID 30mm	STD	1	2300	1500
5	Red Oxide				2 Qtr	800	800
6	Off White Paint				1 Qtr	800	500
7	Motor	-	-	10 hp	1	80000	80000
TOTAL AMMOUNT							**85100**

Table 6.4 BOQ of Equipment

6.2.5 BOQ OF FIXTURES

SHEET#5								
DURABILITY TESTING MACHINE FOR STRUTS								
FIXTURE (178B)								
LOWER								
ITEM NO.	PART NUMBER	CROSS SECTION	LENGTH	MATERIAL	QTY.	Weight	PRICE PER UNIT	PRICE
1	Metal Rod	30mm dia	35mm	k100	2	0.4	1510	604
2	Metal Rod	30mm dia	35mm	k101	2	0.4	1510	604
3	Metal Rod	30mm dia	120mm	SAE1045	2	1.33	262	348.46
4	Metal Rod	6mm dia	40mm	SAE 1010	4	30	198	5940
5	SHC SCREW	M6	30mm	STD	4		25	100
6	Metal plate	30mm*45mm	100mm	SAE 1010	2	2.2	198	435.6
7	Metal Rod	25mm dia	15mm	SAE 1011	2	0.1	198	19.8
8	SHC SCREW	M12	40mm	STD	2		25	50
9	Metal Rod	30mm dia	35mm	K100	2	0.5	1510	755
10	Metal plate	35mm*45mm	145mm	SAE1010	2	4	198	792
11	Metal Rod	45mm dia	70mm	SAE1035	2	1.8	262	471.6
12	Hex Head Screw	M16	85mm	STD	8		50	400
13	Metal Plate	22mm*125mm	205mm	SAE1010	4	8	198	1584
14	NUT	M16		STD	8		8	64
UPPER								

1	Metal Plate	20mm*105mm	125mm	SAE1010	2	5.5	198	1089
2	Metal plate	110mm dia	35mm	SAE1010	2	6	198	1188
3	SHC SCREW	M8	40mm	STD	8		25	200
4	Metal plate	30mm*55mm	85mm	SAE1010	1	1.5	198	297
5	NUT	M10x1.25		std	6		20	120
6	Metal Plate	170mm dia	60mm	SAE1035	2		262	524
7	SHC SCREW	M16	25	STD	4		50	200
							Total	**15,786.46**

Table 6.5 BOQ of Fixtures

6.2.6 TOTAL COST OF MACHINE

SHEET	COST
SHEET #1	Rs 187735
SHEET #2	Rs 17908
SHEET #3	Rs 233270
SHEET #4	Rs 85100
SHEET #5	Rs 157866.46
TOTAL	**Rs 681879.46**

Table 6.6 Total Cost of Machine

6.3 MACHINING PROCESS:

Machining is the process of removing unwanted material from any metal piece in order to create desired shapes. Machining is done on raw material to create final product.

6.3.1 MACHINING PROCESSES INVOLVED IN PROJECT:

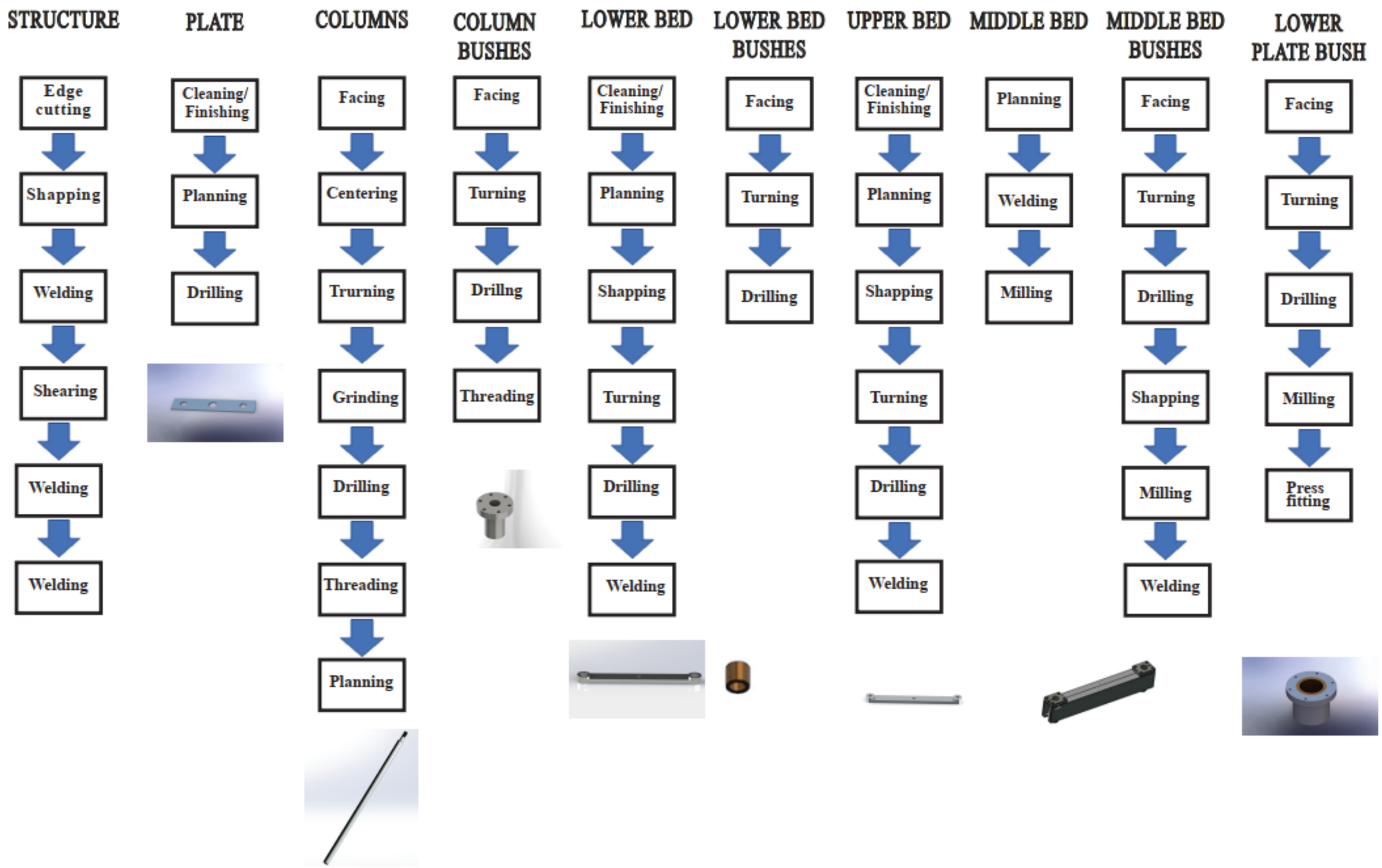
Following are some chips forming processes.

1. Turning
2. Facing
3. Boring
4. Shaping
5. Planning
6. Tapping
7. Milling
8. Drilling
9. Grinding
10. Boring

6.3.2 MACHINING SERVICE PROVIDERS:

S.NO.	SERVICE PROVIDERs	SERVICE(S)	LOCATION
1	Tool Room, Agriauto	Lathe Operations Milling Operations Shaper Operations	AIL, HUB
2	Press Department Agriauto	Planning Operation	AIL, HUB
3	Fabrication Shop Agriauto	Arc Welding Assembly	AIL, HUB
4	Adnan Engineering	Arc Welding Dick Cutter Grinding	Contractor At AIL, HUB
5	Four Wheeler Plant	CO2 Welding	AIL, HUB
6	Nawaz engineering	All Machining Operations On Few Parts	Shershah, Karachi
7	International reclaiming	Grinding Of Columns	Habib Bank Chowrangi , Karachi
8	Ahtisham engineering	Crank Wheel	Al Hasan , Nazimabad , Karachi

6.3.3 PROCESS FLOW



PROCESS PLAN

6.4 ASSEMBLY

Assembly refers to the joining, connecting and attaching of all parts, Components, equipment etc to obtain the final shape of the machine.

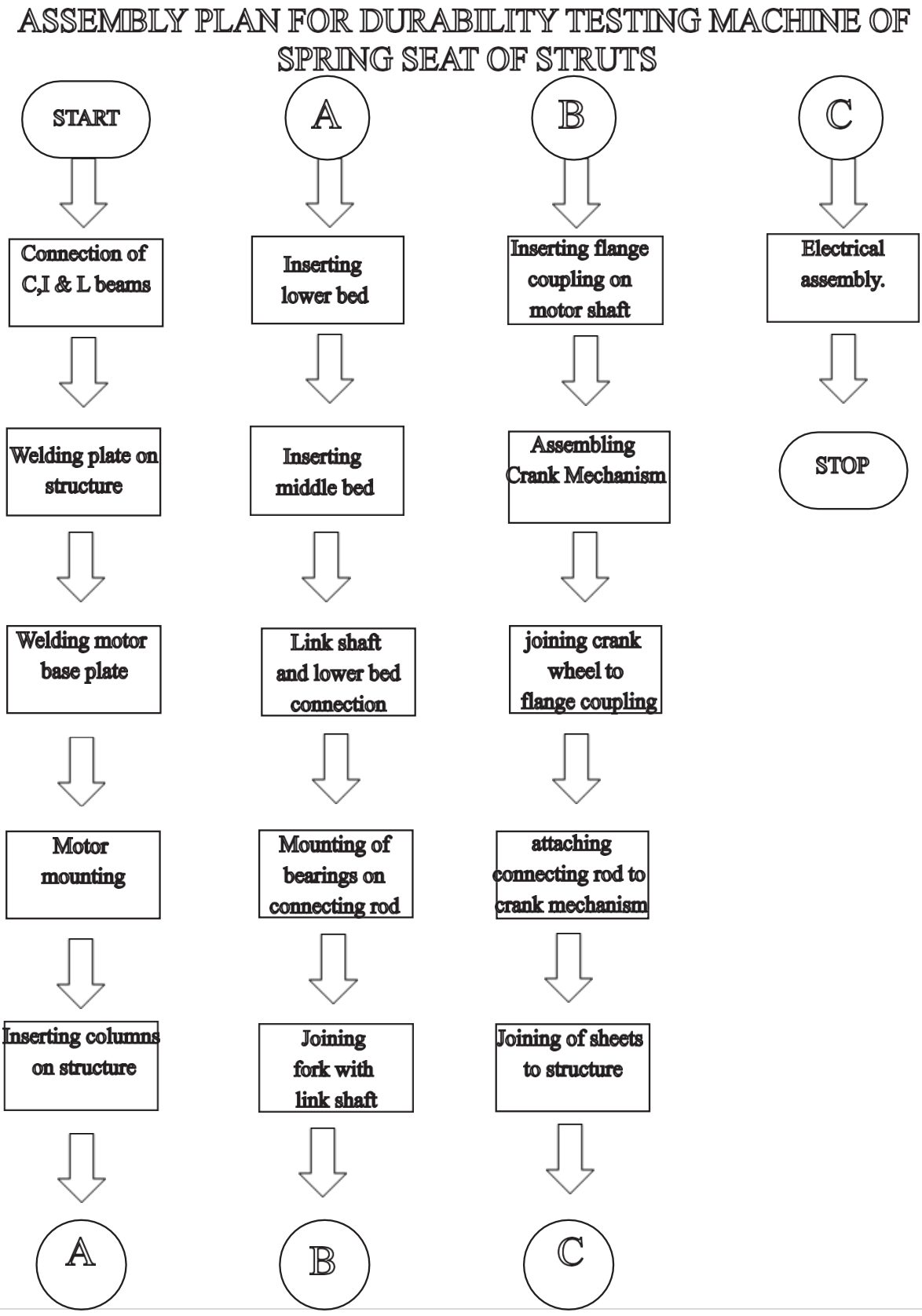
6.4.1 SUBASSEMBLY

We carried out the subassembly of individual parts (Structure, Cotter knuckle joint etc) all along the fabrication process. Subassembly of all individual parts were started just after the completion of machining of components.

6.4.2 FINAL ASSEMBLY

The final assembly was done in Fabrication Shop Ail. Our team was present there for the entire process of assembly and guided the fabricator. All beds, fixtures, etc. were assembled to form the machine. The process sheet of assembly is attached.

ASSEMBLY PLAN



6.5 TEST AND TRIAS:

6.5.1 IDLE TRIAL

Our team performed final IDLE TRIAL (run the machine without load) in order to check the smooth running of reciprocating and rotating components. Problem were found in middle bed, motor base and some other parts.

We made necessary changes and then performed SECOND IDLE TRIAL, which was successful.

6.5.2 LOADED TRIAL

Loaded trial of machine was held at AGRIAUTO industry ltd. Our group was present at Plant maintenance department. Two samples of products, to be tested by machine, were obtained and installed on machine. The machine run smoothly and all components worked as they were supposed to do.

CHAPTER 7

7) CONCLUSION

7.1 SUMMARY

We worked on the design and development of a durability testing machine for spring seat of struts. All the milestones of the project were completed on time and with accordance to the requirements specified by Agriauto, Toyota and Suzuki.

In the time given to us, we were able to design an assembly that exceeded 500 parts. We conducted Ansys structural analysis of all machine parts and we were also successful in conducting a motion study of the machine on Solidworks. The staff of Agriauto were kind enough to sponsor this project upon seeing the effort that we put into it.

Now the machine will be placed in the Design and development department of Agriauto under the supervision of very talented engineers.

7.2 FUTURE RECOMMENDATIONS

Although we were required to only develop a machine for three samples (see table 4.1 and 4.2), we were able to design it such that it can incorporate and test any product that is being manufactured in Agriautos. (Provided that the fixtures are fabricated)

Moreover, if some adjustments are performed, it can also be used to execute a number of other tests. We discussed this in detail with Mr Kalimullah (GM Tech Agriauto).

Agriauto should also hire more final engineers from NED university to develop the rest of the testing machines so they don't have to depend on KYB Japan. This is a mutually beneficial situation for both parties.

7.3 CONCLUDING REMARKS

We have experienced so much growth throughout this project and we are forever grateful to the cooperative staff of Agriauto who helped us at every turn. Surely, Kaizen is a way of life over there and now it has also become a part of us too.

We will reflect on this experience with fond memories and we will apply all that we have learned here throughout our career. No amount of gratitude can ever do justice to the unconditional aid and cooperation provided by Agriauto.

REFERENCES

[1] Suspension by Dustin Hawley-Feb 15, 2021

[2] Automobile Suspension (Car Suspension) By kartik Rangam -March 31, 2020

[3] Beginners' guide to car suspension types -Autodeal on May 14, 2021

[4] "Chapter 23 Springs" of Machine Design by Khurmi and Gupta 14th edition

[5] "Chapter 10 Mechanical Springs" of Machine Design by Shighley 8th edition

[6] "Chapter 20 V-Belt and Rope drive" of Machine Design by Khurmi and Gupta 14th edition

[7] "Chapter-26 sliding contact bearing" of Machine Design by Khurmi and Gupta 14th edition

[8] "Chapter-27 rolling contact bearing" of Machine Design by Khurmi and Gupta 14th edition

[9] "Chapter 11 rolling contact bearing" of Machine Design by Shighley 8th edition

[10] "Chapter 12 lubrication and journal bearings" of Machine Design by Shighley 8th edition

[11] "Chapter 2 Materials" of Machine Design by Khurmi and Gupta 14th edition

[12] "Chapter 5 torsional and bending stresses in machine parts" of Machine Design by Khurmi and Gupta 14th edition

[13] "Chapter 6 Variable stresses in machine parts" of Machine Design by Khurmi and Gupta 14th edition

[14] "Section II Failure prevention" of Machine Design by Shighley 8th edition

[15] "Chapter 10 welded joint" of Machine Design by Khurmi and Gupta 14th edition

[16] "Chapter 11 screwed joints" of Machine Design by Khurmi and Gupta 14th edition

[17] "Chapter 8 Screws, Fasteners, and the Design of Nonpermanent Joints" of Machine Design by Shighley 8th edition

[18] "Chapter 9 Welding, Bonding, and the Design of Permanent Joints" of Machine Design by Shighley 8th edition

[19] "Chapter 21 Chain drive" of Machine Design by Khurmi and Gupta 14th edition

[20] "Chain drive" by Machine elements in Mechanical design by Robert L. Mott, Edward M. Vavrek and Jhywen Wang

[21] "Chapter 12 Cotter and Knuckle joint" of Machine Design by Khurmi and Gupta 14th edition

[22] "Chapter 13 Keys and coupling" of Machine Design by Khurmi and Gupta 14th edition

[23] "Chapter 14 Shafts" of Machine Design by Khurmi and Gupta 14th edition

[24] "Chapter 6 Bending stresses" of Mechanics of Materials 8th edition

[25] "Chapter 2 Stress" of Mechanics of Materials 8th edition

[26] "Chapter 11 Design of beams and shafts" of Mechanics of Materials 8th edition

[27] IKEA Bearing catalogue

[28] Zumasun Steel catalogue

[29] "Chapter 16 columns and struts" of Machine Design by Khurmi and Gupta 14th edition